Solar water distillation - Zambian perspective

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SOLAR WATER DISTILLATION systems produce clean drinking water from polluted water and are suitable for remote regions. A simple solar still comprises a shallow depression in the ground to contain the polluted water and a transparent cover placed over the depression. The system uses the greenhouse effect to evaporate the water by incoming solar radiation and the resulting condensation forming on the inner surface of the cover is collected. The condensed water is free of any chemical and biological contamination. Although solar water distillation is effective and solar energy is clean, safe and viable in many countries, it has not found wide-spread use due to high capital investment. In Zambia the problem has been compounded by lack of awareness about renewable technologies, inadequate adaptive research on solar distillation technology to the Zambian situation and lack of demonstration projects. For the people in rural areas who boil their drinking water, firewood is the only source of energy. In view of the current concerns of environmental pollution, deforestation and health hazards caused by the burning of firewood, and because few rural Zambian communities are connected to the national electricity grid, solar water distillation has a potential for wide-spread use.

Introduction

It is estimated that 30% of the rural population and 70% of the urban population in Zambia have regular access to safe supplies of drinking water. The problems faced by water suppliers in Zambia include lack of an adequate institutional framework and an absence of standardised pumping technology and water point designs. Urban water suppliers face additional problems due to proliferation of illegal settlements in particular on rich water aquifers and illegal discharges of effluent into water sources (Ministry of Energy and Water Development, 1994a). Even in planned localities of urban areas, tap water may not be safe to drink due to possible contamination from septic systems, industrial pollution and run-off from fertilizers and pesticides. People have to either boil the water, or treat it with chlorine, to kill bacteria before drinking, although this does not remove salts and minerals. Boiling the water requires heating from electricity, firewood or charcoal and these are increasingly becoming more expensive. Unlike urban settlements, many rural Zambian communities live in scattered and distant homesteads with low population density, which makes it difficult for them to be connected to the national electricity grid. They use biomass (wood, charcoal, and other biological matter) for cooking which has been found to cause deforestation and health hazards during burning. Indoor air pollution from smoke, charcoal, wood and other biomass is considered a major contributor to respiratory diseases (Karekezi and Ranja, 1997). The burning of biomass generates large amounts of CO_2, which is one of the so-called greenhouse gases responsible for depleting the ozone layer and causing global warming. Charcoal production pollutes the soil and reduces soil moisture content, and consequently, decreases crop production.

Among the technologies developed to increase the availability of fresh water to remote arid regions, distillation is probably the only one that produces pure water that is free of any chemical and biological contamination. Distillation requires a source of energy input as heat and solar radiation has been shown to be a potential source. The use of solar energy is more economical than fossil fuels in remote areas with low population densities and abundant solar energy. Studies have shown that the practical application of solar stills is limited to sites with sunny climates, relatively low water requirements and high fuel costs (Kudish, 1991). Solar stills require minimal skilled labour for operation and maintenance. Although solar distillation technology has been in existence for more than 2000 years, mass production of solar stills only occurred for the first time during the second world war when 200,000 inflatable plastics were made for the US Navy (Hislop, 1992).

Solar stills are in operation in many developing countries including African and in particular, South Africa where a company manufactures them on mass scale. However, the author is not aware of any solar stills in operation in Zambia.

System operation

Solar distillation uses sunlight to heat water and produce water vapour which is then condensed back into water. The basic operation of a solar still (Figure 1) is that water to be distilled is contained in an enclosure which has the top cover made of glass or some other transparent material and the cover is inclined at an angle. Direct sunlight heats up the water in the basin through the bottom of the basin and this causes the water to evaporate. The water vapour then condenses on the glass cover since the cover is in contact with the cooler outside air. The resulting liquid water runs under the glass cover and is collected. Impurities such as salts, minerals, heavy metals and bacteria will not evaporate and are left behind. The still therefore has to be flushed regularly to remove the impurities. This can be done by

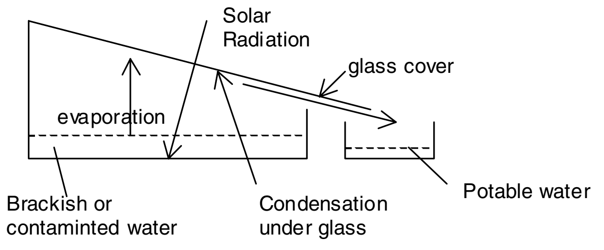

Figure 1. Solar Still

fitting overflow outlets to the still and filling it everyday with twice as much water as was produced so that the excess water flushes the still.

The approximate output of a solar still is given by (Hislop, 1992): $Q = 1.6e\, AI_d$

where Q = daily output of distilled water, litres/day

e = overall system efficiency, typical 30%

I_d = average daily solar radiation, kWh/day

A = aperture area of the still, m^2.

A 1m^2 size solar still produces 2.5 litres of clean drinking water per day in Zambia where, Lusaka for example, has a yearly average daily global solar radiation of 18.024 MJ/m^2 (Reddy, 1987) and an average daily sunshine of about 10 hours (Meteorological Department, 1972).

Barriers to the uptake of Solar Distillation Technology

The initial cost of solar stills is regarded as the single biggest barrier to their widespread dissemination with costs ranging between US$84 to US$110 per m^2 (Hislop, 1992). The material cost of a 1-m^2 solar still based on major construction materials (Table 1) available in Zambia is about US$33. The cost of pure water produced depends on the cost of making the still, the cost of land where the still operates from, the life of the still – about 20 years, the discount rate, the operating costs, the cost of feed water and the amount of water produced. The non-existence of solar stills in Zambia has been compounded by lack of awareness about renewable technologies, inadequate adaptive research on solar distillation technology to the Zambian situation and lack of demonstration projects.

Breaking the barriers

Some of the ways of improving the uptake of solar distillation systems are to have:

- Community supported demonstrations of solar stills with sufficient back-up in order to raise awareness and demand for the technology;
- Self-sustaining financing of solar stills through banks, existing credit institutions and water suppliers;
- Organised training of solar still systems installers, distributors, sales agents, community leaders and end users;
- Continuous awareness raising of solar still technology by Government, research institutions, communities, the private sector and NGO's; and
- Regional collaborative research in solar distillation systems in order to avoid repetition of work and therefore advance ideas.

In addition to the above strategies, the use of as many local materials as possible including recyclable ones should be encouraged in order to reduce the cost of the stills.

Conclusions

Solar still technology is new to Zambia and must not be viewed in isolation but in terms of the global energy scene. Alternative and renewable energy sources, especially solar energy, are becoming increasingly important because they do not pollute the environment and are diffuse in nature. Renewable energy technologies are particularly important to rural areas of developing countries like Zambia where people live in scattered homesteads which makes it very difficult for the Government to service these communities with water, energy and other amenities. The potential for solar distillation in Zambia exists with the Ministry of Energy and Water Development (1994b) having recognised the need to promote new and renewable sources of energy through many ways including research and development, training and practical demonstrations and pilot schemes. It is up to the research institutions and other stakeholders to come together and demonstrate the benefits of this technology to the Zambian community.

Table 1. Local major construction materials to build a 1m^2 Solar Still in Zambia

Material	Cost US$
Glass (4 mm standard window type)	8.60
Steel (1.2 mm flat sheet)	17.15
Matt Black Paint	3.45
Silicone Sealant	3.45

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