Safe Drinking Water for All

Drinking Water in Third World Villages

Alternative Techniques Using Renewable Energy Sources

by K S Rabbani

MANY people, particularly children, die of waterborne diarrhoeal diseases in the Third World. Each year, about three hundred thousand children under the age of five are killed by this disease in Bangladesh alone. Situations occur, particularly during and after natural calamities like floods and cyclones, when conventional means of providing pure drinking water become impractical due to problems of either technical or logistic nature. This paper puts forward a few alternative techniques for obtaining diarrhoeal germ-free drinking water that use renewable energy sources and which can be adopted during emergency or in normal situations.

Destroying Diarrhoeal Pathogens

Boiling is usually prescribed to purify water. However, this is not absolutely necessary. All diarrohoeal pathogens in water are destroyed in 30 minutes at 60°C. At higher temperatures the process is much faster. Table 1 gives a collated summary of bacterial sterilisation in water (Hynes, 1968; Chowdhury, 1988). This is also the basis of pasteurisation (30 mins at 63°C or 15 secs at 70°C). These temperatures are achievable in simple solar water heaters and solar water purification appears to be a practical proposition.

TABLE-1: Minimum temperature and duration needed to destroy waterborne diarrhoeal pathogens

Pathogen	Disease caused	Destruction
Salmonella group	Typhoid, paratyphoid	20 mins at 60°C
Vibrio Cholera	Cholera	15 mins at 55° C
E. Coli group	Diarrhoea	20 mins at 60°C
Shigella	Dysentry	1 hour at 55°C
Rota Virus	Infantile diarrhoea	30 mins at 60°C

Solar Water Purification

The Low-cost Model: In designing this model, the following points were considered. a) The unit has to cost as little as possible. b) Materials should be readily available in rural areas. c) Technology should be simple, within the reach of a common village man. d) The unit should be usable in situations of emergency, e.g., during floods and after cyclones, etc. e) It should be able to raise the temperature of at least a few litres of water to more than 60°C.

The main innovation in obtaining high overall temperatures using such a simple device was in having a thin water layer laid horizontally. Since hot water collects at the top by convection, the bottom layers will only heat up by conduction from the warmer layers above. If the water layer is too thick, the bottom layers remain considerably cooler (Rabbani et al, 1985). During the course of this work, it has been experimentally found that a layer thickness of less than 3/4" is required to obtain requisite temperatures at the bottom layer. Several designs were tried and the device chosen is shown in fig. 1a. The cross sectional schematic is shown in fig. 1b. However, a similar configuration based on other materials are equally feasible.

In fig. 1b, AB is a circular bamboo tray, about 2 feet in diameter, and placed on a bed of hay about 4 inches thick. This type of tray is cheap and is widely used in Bangladesh villages for drying food items in the sun. The inside of the tray is painted black using any common paint. Alternatively a blackened paper or plastic sheet laid on the bottom of the tray would do. A thick polythene sheet about 4ft square is first laid on the tray (p in fig. 1b). This forms the water reservoir and two to three litres of water is poured onto this (q). A second polythene sheet (r) is laid on the water surface. Any trapped air bubble is removed by lightly rubbing with a finger from the centre outwards. If there are air pockets, water vapour will condense under the sheet and will obstruct passage of solar energy. A few strands of thick straw (s) is spread randomly on this sheet over which another polythene sheet (t) is spread out. The strands of straw help maintain an air gap between these two layers of sheet. A further cover of polythene sheet (v) is spread out with similar straw strands (u) in between. This whole assembly of polythene sheets is kept stretched by pressing on the outside using a thick ring of twisted hay (w) on which some weights may be placed if necessary. The arrangement essentially forms a flat plate water heater with double transparent covers. The polythene sheets that are used as covers should be clear. Transparent pvc sheets are clearer than polythene sheets and may be used to give better performance, if available.

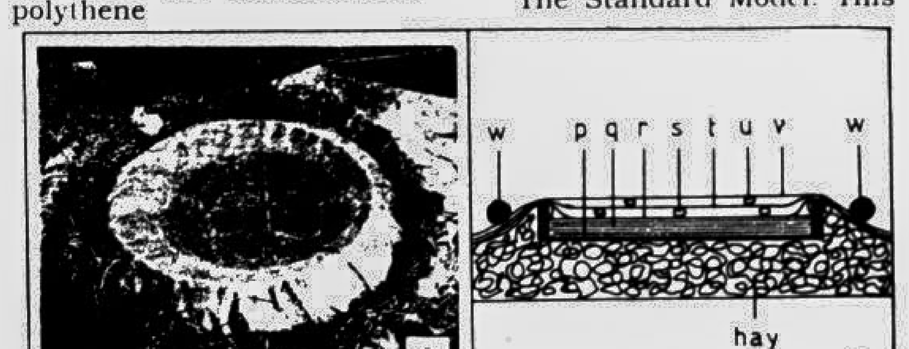

Fig.1. A low cost solar water purifier (a) and its cross sectional schematic (b).

An alternative arrangement uses a transparent polythene bag to hold water which is first placed flat on the painted tray. Another design uses water inside a flat coil of 1/2 inch dia transparent pvc tube with both ends tied up. The advantage is in easy handling of water. However it might become difficult to keep them clean and dry when not in use. Any tray like structure, even a cardboard box with hay or saw dust put inside, may be used instead of the bamboo tray. A tray made of polystyrene foam makes a good alternative if available, since it does not need any extra insulation. The insulation should be as good as possible since this determines the maximum attainable temperature. Hay, which traps lot of air has been found to perform well. A double transparent cover has also been chosen for this reason. A single transparent cover may be adequate at places with high solar insolation. A white cloth or a mat hung vertically beside the collector at an appropriate direction will reflect sunlight and boost the incident energy. These simple devices can even be installed on rafts during floods.

The Standard Model: This model is basically a conventional flat plate water heater with thermosyphon storage. However, the technology is entirely indigenous. The absorber (6ftX3ft) is made out of two parallel # 24 SWG galvanised iron (GI) sheets 1/4" apart. To maintain the separation all through, dents were made on both the sheets at suitable intervals and welded. The inlet and outlet pipe connections were made on the bottom plate at suitable points with extra reinforcement on the sheet. To resist corrosion, thinned Nitrocellulose paint (NC paint, also known as car paint) was introduced into the absorber through the inlet and the whole assembly was tilted up and down to get a coating on the inner surface. The collector frame was made of # 16 SWG GI sheet and polystyrene foam was used to insulate the absorber. A single transparent acrylic sheet (PERSPEX) was used as the front cover. However to prevent it from sagging in the middle the sheet was fixed with a slight convex bulge. The collector was fixed at an angle of 35° with the horizontal, facing south (latitude of Dhaka: 23.5° north). The storage tank (40 litre capacity) was made of GI sheets and had double walls with polystyrene foam insulation.

Rainwater Collection

A simple method for increasing the collection area has been proposed using polythene sheets (Rabbani 1991) and shown in fig 2. A four to six feet square sheet is tied up on all four corners to posts dug into the earth. A hole in the centre discharges the collected water into a reservoir below which can be a pitcher or tumbler. This can even be used during floods by erecting the device on a raft. An alternative to the polythene sheet is a clean sheet of cloth with a weight placed at the centre. This collects and filters the water simultaneously and has been used 30 to 40 years back in some areas of Bangladesh but is forgotten now. A 4'x4' sheet will collect about 15 litres of water for 10mm of rainfall.

Performance

The performance of various designs of the low cost water purifier are given in Table 2. Temperatures were measured using thermistors placed between the bottom layer of polythene and the blackened tray. The heating performance of the standard model on a relatively clear day and that on a very cloudy day (with rains in the morning) in August are shown in fig 3. The appropriate solar insolation (Global, Horizontal) are also shown on the curves.

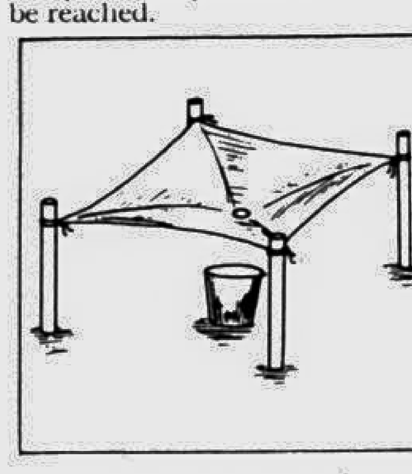

Fig.2. Rainwater collector.

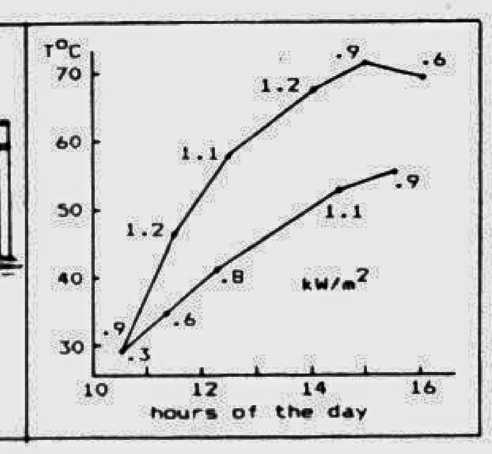

Fig.3 Performance of the standard Solar water purifier.

The standard flat plate collector has performed very well. About 55°C was obtained even on a cloudy day with rains in the morning. This could be used in a common facility like a rural health centre or a school and maintained by trained staff. The design has survived for about five years without much deterioration of the PERSPEX cover or in the absorber.

Table 2. Performance of low cost solar water heaters. (Maximum temp. obtained in January)

Type of solar water heater	Heating period	Temp.°C
Polystyrene tray, 1" thick wall, 1/4" water layer, double transparent PVC cover	11 am to 1 pm	72
As above, single PVC cover, with single white reflector	10:45 am to 12 noon	64
Cardboard box with 6" saw-dust insulator, 1/4" water, single PVC cover	12 noon to 1:30 pm	64
Bamboo tray, 3" hay insulator, 1/2" water single polythene cover	11:10 am to 1:40 pm	60
As above, double cover (one PVC, one polythene)	11:10 am to 1:40 pm	68

Discussion

From the results presented in Table 2 it appears that the low cost design have succeeded in achieving the requisite temperatures even in January when sunshine is minimum in Bangladesh (Declination: ~40 deg). During periods of intermittent sunshine a thinner water layer could be used to reduce the heating time. At least two harvests can be obtained per day using these designs thus doubling the quantity. This would be particularly useful for children and patients in a family. This technique should not be tried on cloudy days since adequate temperatures will not be reached.

The solar technology and rainwater collection could form the basis of an alternative approach for providing drinking water through most of the seasons excepting periods with non rain bearing clouds. If the required materials are stocked as a part of a disaster preparedness programme, they could save a lot of lives.

The author professor, Department of Physics, University of Dhaka. He wishes to thank Dr. Nazrul Islam, Ex-Professor of Pathology, IPGMR, Dhaka for helpful discussions and the research students who were associated at different stages of the work.

All the discussions on this issue could not be accommodated for space constraint. The remaining write-ups, however, will appear in our Focus/Features pages.

SAFE BOTTLED WATER

Need for Microbiological Quality Control

by Dr Sirajul Islam Khan

WATER is an absolute necessity for life. Microbiological concentration and quality of water varies according to its source, supply, storage condition and susceptibility to contamination by pathogens of various types including extremely harmful bacteria. Underground and spring water undergo natural filtration and can be considered safe for consumption subject to nature of extraction, treatment strategies, distribution, storage and handling. Other potable water sources for example, surface water, have a much greater chance of being a carrier of pathogens of waterborne diseases. Stringent and relatively expensive treatment approaches have to be employed for assuring quality of potable water derived from river, lake or any other surface reservoir. In most cases, hand-pumped tube-well water in villages are most often not free or within permissible limits of microbial contaminants. Research carried out by the Department of Microbiology, University of Dhaka, couple of years back give credence to the above statement.

There are various factors related to environmental pollution, that determine the level of microbial contamination. Although soil strata serve as natural filter, leakage or seepage of sewage or polluted effluents of both household and industrial origin leach out into the ground water and contributes to pollution.

City water supplies in our country are also not free of harmful microbiological contamination. Even though more than 90 per cent of these supplies constitute groundwater as source, after extraction the water is hardly treated or disinfected and thus becomes susceptible to microbial contamination particularly when supply pipe lines are leaked or come in contact with sewage discharge lines. The WASA water supply is contaminated when distribution pipes form microbial biofilm that further contributes to contamination by pathogenic bacteria. Recent findings by the Department of Microbiology, University of Dhaka, has revealed alarming level of microbial contamination in piped water supply overseen (or not seen!) by WASA authority.

An Alternative Source of Potable Water

Due to the poor quality of piped supply water, people are now looking for an alternative source of water free of attendant pathogen. Quality bottled water may serve quite well as an alternative source — particularly for people having less financial constraints. Introduction of bottled water as a commercial venture in the western countries materialised long ago. In Bangladesh production of bottled water started only about 7-8 years back. Its sale has tremendously increased throughout the world including Bangladesh, in the last few years. In part, this increasing market is the result of public concern about the safety of supplied piped water.

Bottled water may be of two types — untreated and treated. It can also be carbonated or still (not carbonated). In some cases the water is collected directly from underground or natural springs and bottled without any treatment at the site of collection. Another way is to treat the groundwater in different ways i.e. gravel-sand filtration followed by ultraviolet (UV) radiation, chlorination or ozonation or by other chemicals. Some bottled water companies gravel-filter the extracted ground water and expose it to UV-ray and/or apply ozone treatment. All these treatment strategies are applied to ensure removal of pathogenic microbes or bring them to a level as recommended by US EPA, EC or WHO.

Removal or destruction of all microbes or attendant pathogens during filtration, bottling or storage is absolutely impractical. The incidence of pathogenic microbes in bottled water is indirectly assessed by the detection of "indicator bacteria" of various types, the number of which correlates with the presence of pathogens in potable water. The 'coliform concept' in water quality assurance has lost its importance and credibility over the years because of natural adaptation of certain member of coliforms even in pristine environment. A long list of indicator organisms are now-a-days recommended by the US EPA and other agencies with their acceptable limit values. Certain types of indicators i.e. HPC bacteria are allowed at a concentration of 50,000 per 100ml of potable water while others should be zero or between 0-10/100ml depending on types of indicator, treatment, source, nature and quantum of supply.

Unfortunately the scenario with the most bottled water produced in our country often falls short of requisite standard. Of late dozens of companies have started commercial production of bottled water and are doing brisk business. Microbiological examination for all these marketed bottled water of various brands await close monitoring and assessment by the Department of Microbiology, University of Dhaka.

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Arsenic-free Water

by Alternative Correspondent

SOUTH Asian experts are coming up with their own answers against arsenic contamination. In India a project has recently been undertaken by a BEC team, widely appreciated as a cost effective and sustainable method of removing arsenic from contaminated water. This was reported by the *Statesman* in its issue of March 1 1998. The process involves the use of activated alumina, a promising medium for fixed-bed operations directed at removing arsenic from ground water. Over the past two years, the project masterminded by late Dr. Amar Kumar Datta of West Bengal, India, has developed removal units that utilize activated alumina, the advantage lying in non-use of electricity and no maintenance complications. The performance of this new technology in India has so far proven that the process can be employed on a full scale basis.

On the feasibility of using such technology in Bangladesh, Dr. Ainun Nishat, a leading water expert of our country, maintained that if more substantial evidence can be gathered about its performance then the technology may be tested in the field. He further opined that the technology appeared to be within the reach of the common people.

Dr. Nishat suggested certain other measures to fight arsenic contamination. In this regard he emphasized relying on surface water rather than ground water. For this he suggested reviving the process of storing fresh water in well-protected ponds and using it after cleaning. In such ponds only selected small species of fish should be allowed to grow which will eat up mosquito larvas and other organisms. The banks of these ponds ought to be high raised so that flood water cannot enter. He further mentioned about the process of refining water by passing it through a series of filter tanks which was used during the 1980s to refine water in the coastal areas. Thirdly, Dr. Nishat spoke about household basis storage of rain water in large pots, a method used in water scarce countries. This method should be popularized among the villagers.

Recent estimates suggest that nearly 75 million people of Bangladesh are at risk of arsenic contamination. There is no parallel in the world of such a huge population being affected by supply of drinking water. The vital challenge for us now is to devise strategies to fight against the devil's water. Researchers and scientists should come up with more innovative and appropriate mechanisms if we want to avoid a disastrous future for our posterity.

Our next issue of '*Alternatives*' focuses on Public Toilet. Creative suggestions are invited from our esteemed readers. —Editor

A South Asian Manifesto on the Politics and Knowledge of Water

by Imtiaz Ahmed, Ajaya Dixit and Ashis Nandy

THE last fifty years of water management in South Asia has been the story of unfolding disaster. Due to mismanagement the quality and quantity of water has declined. This is linked to environmental and economic degradation in the region; it has also affected the future relations between the states of the region. In short it has been a classic case of misgovernance. In light of the above we make the following propositions in an attempt to at least think about the restructuring of the political economy of water in South Asia.

Water and Governance: Water scarcity in South Asia is due to misuse and mismanagement of water and natural resources by the state. The present construction-led water development has benefited the rich; while it marginalised the poor. It has failed to provide fresh drinking water to the general people. Shortage of water has also affected the foundations of social and community life by forcing the migration of the rural poor into the overcrowded cities. This adds to the level of pollution and further strain the supply of fresh water.

Science, Uncertainty and Risks: A complex relationship exists among water, nature and human intervention. In order to comprehend this fully an integrated approach comprising of pure science and technology, sociology and politics is needed. It is important to sensitise the science of water management to social realities.

The natural sciences involve huge alterations in water structure, which affects its volume, location and quality. On the other hand, South Asia's hydrology is inherently uncertain. Such uncertainty is exacerbated by the unreliability of data. Massive water development projects have often been undertaken based on western models and insufficient data. These borrowed models are often out of tune with the realities of the region.

The Hubris of Modern Technology and Global Capital: Modern technology is inextricably linked with and dependent on global capital. Capital seeks quick returns, not bottom-up initiatives necessary for self-reliant change. Moreover it operates within a centralised system which is closer to the rich and the powerful. Consequently the large water resource projects drives a wedge between the investors and the general people dependent on water.

Dams and Profitability: The West has largely come to realize the unprofitability of large dams. They are increasingly criticized for being economically unsound, socially harmful and environmentally hazardous. In South Asia this knowledge is however yet to seep through in the public discourse. Consequently the vested interest group that stands to reap profits through these constructions, i.e., the contractors and the politicians keep on perpetuating the myth that large dams are the only means of ensuring water security. Therefore, any attempt to promote sustainable alternatives must take into account the relationship between knowledge and power, and the politics of it.

Water and Equity: Water development ventures in South Asia, for example dams, reservoirs and canals has benefited the majority community at the expense of the minorities especially the indigenous people. In most instances they have been displaced from their lands with no or very little compensation. These constructions also opened up their lands to external intrusion, which thoroughly disrupted their cultural and social lives. In extreme cases it gave birth to sub-nationalism and violence.

Women in South Asia have traditionally played a critical role in water conservation and management. But this has now been taken over by the "masculine reductionist science" which has led to the displacement of women from their traditional role. This has not only marginalised them; but has also distorted the basic configuration of the cultures in this part of the word.

Water Insecurity and the Costs of Water: Water insecurity is linked to environmental insecurity and social uprooting. This affects the poorer section of the community the most. The situation is made worse for them by the rapidly growing cost of supplying water. In the rural areas it is the elite who usually controls the water pumps. Water is sold at exorbitant prices. The poor thus have no easy access to water. They also are the worst sufferers of water-borne diseases. This further strains the already meager health budgets of South Asian states.

Decentralising Water Management: Centralised water management and development is often negligent of local needs. Water has been turned into a national security issue; thus disassociating it from its actual use. This has led to lack of transparency and absence of accountability. Since the resources themselves are naturally decentralised, it is important that water management and development too be decentralised and brought under the control of local government and monitored by the civil society. Devolution of political power for decentralised management is bound to bring about innovative and creative changes in water management and development

Denationalising Water: South Asian states have nationalised their water resources, though water seldom remains within the jurisdiction of national boundaries. Nationalisation of water has brought untold sufferings to the people. For instance, this perpetuates the propensity for rent-seeking and has led to the creation of "water lords" in eastern India. The construction of the Farakka barrage has not only harmed the population of Bangladesh but has also brought devastation in Bihar and West Bengal. Construction of large dams is seen as symbols of "national development" whereas as pointed out earlier they are the cause of much human miseries. Denationalising water would free water from the power of the state and the culture of the state.

Rivers Rights: Rights of the rivers must be codified and guaranteed by the state and the people. Such rights have already been codified for oceans and seas. These would help keep the rivers relatively pollution-free and provide a safe habitat for riverine forms of life, and allow it to flow freely within limits. Large constructions and diversions not only interfere with the natural flow of water; but also put the ecology and economy of the area into jeopardy. It has caused immense sufferings to the people, especially the indigenous communities, which in turn has led to the creation of environmental refugees.

Towards an Integrative Vision: So far the approach to water management and water development has remained fragmentary. It is our belief that water management must be based on the recognition of the wholeness of water and its intrinsic function in nature. In order to bring about the change interventions must be based at all levels. To begin with it must be integrated at all levels of our academic curriculum. There is a need to integrate the global and the local. Plurality of views and options must be sought. Most importantly in order to have a more secure future for water there ought to be participatory, consensus-seeking, democratic, accountable governance.

This is an abridged version of the Manifesto. Imtiaz Ahmed teaches international relations in Dhaka University; Ajaya Dixit is a water resources engineer working with the Nepal Water Conservation Foundation, Kathmandu; and Ashis Nandy is a political psychologist and former Director, Centre for the Study of Developing Societies, New Delhi.