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WATER AND SANITATION FOR ALL: PARTNERSHIPS AND INNOVATIONS

Innovations in solar water treatment

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WHILE SOLAR WATER disinfection has been the subject of a number of studies over the past few years (Wegelin *et al.*, 1994), it is only recently that the significance of the oxygen status of the water has been appreciated. Laboratory experiments have shown that the effectiveness of sunlight inactivation of faecal bacteria in plastic drinks bottles containing sewage-contaminated water is strongly dependent on the dissolved oxygen content of the water (Reed, 1996). These results suggest that sunlight and oxygen can act together to reduce the counts of faecal microbes in water. For relatively clear waters (i.e. with no substantial turbidity or colour), the proposed treatment regime (Reed, 1997a) is as follows:

- fill each bottle with (contaminated) water, to around three-quarters of its volume, early in the morning;
- replace the cap and shake each bottle for a couple of minutes, to ensure it is saturated with oxygen;
- leave the bottles in full sunlight until dusk, with occasional shaking, to maintain the oxygen content of the water (shake on at least four occasions during the day);
- store the bottles overnight, for use the following day.

The method relies on photo-oxidation, requiring full sunlight and oxygen-saturated water for maximum effect. It is most likely to be of use as a small-scale, self-help measure for people living in countries with consistently sunny climates, in places where there is no alternative means of water treatment.

Applications of solar photo-oxidative disinfection

There are two groups of people who may benefit from the successful implementation of solar water treatment:

1. People in communities presently unserved by other means, e.g. rural villages, shanty dwellers, or refugees - perhaps in response to a specific contamination event (e.g. an outbreak of water-borne disease), or as part of a longer-term approach to hygiene and water-borne disease control.
2. Babies and young infants, without access to a safe water supply - this group is at greatest risk from severe diarrhoeal disease, with estimates of up to 6 million deaths per year in the under-fives (Thielman and Geurrant, 1996).

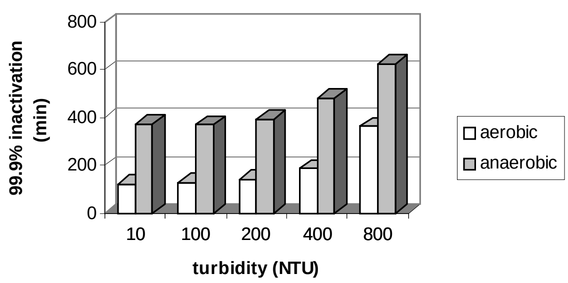
It is worth considering the second of these groups in a little more detail. It seems likely that parents will be most willing to take active steps to reduce the risk of disease and death of their children in their early years: in the absence of any alternative method, solar water treatment may offer them an opportunity to lower the risk of water-borne disease at the household level, without the need for large scale financial support. This proposal is supported by the results of controlled field trials in Kenya (Conroy *et al.*, 1996), where solar disinfection was shown to be effective in reducing the incidence of diarrhoeal disease among Maasai children who drank solar treated water. The authors suggested that the most likely reason for the decrease in illness was the pasteurizing effect of solar heating, since water temperatures of up to 55°C were recorded. Such heating effects would provide additional benefits, alongside solar photo-oxidation.

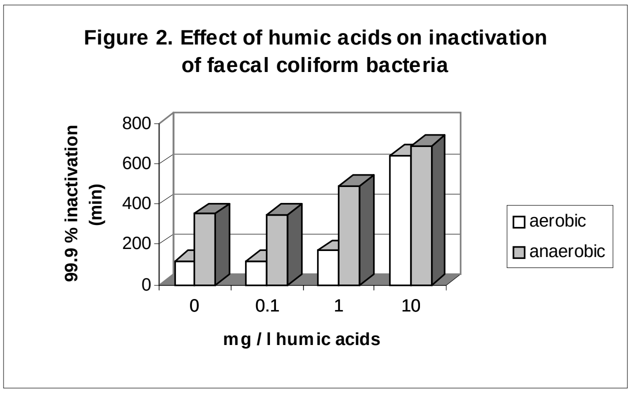
Experimental work and results

Peliminary studies on solar photo-oxidation (Reed, 1996) used relatively clear water, with no significant turbidity or colour. Since either, or both, of these factors will decrease the penetration of sunlight into the water, they are likely to reduce the effectiveness of solar water treatment. This has been studied in the UK, under controlled laboratory conditions.

The influence of turbidity (suspended particulates) on the time required to inactivate 99.9 per cent of faecal coliform bacteria ($T_{99.9}$) in sewage-contaminated water ($\simeq$ 1 per cent raw sewage) has been studied using standard microbiological procedures, based on membrane filtration and lauryl sulphate growth medium (Anon. 1994; Reed, 1997b). The effects of turbidity, due to added kaolin, are shown in Figure 1. In water with no added kaolin (10 NTU), the aerobic sample clearly showed a faster rate of

Figure 1. Effect of turbidity on inactivation of faecal coliform bacteria





inactivation of faecal coliforms, with a 99.9 per cent inactivation time ($T_{99.9}$) that was around a third of that for the anaerobic water sample at the same level of turbidity. However, the difference between the aerobic and anaerobic treatments became less pronounced with increasing turbidity: at 800 NTU, the inactivation time of the aerobic water sample was over one-half of the value for the anaerobic water sample.

The effect of dissolved coloured substances was studied by adding humic acids, at up to 10 mg/litre: the results were broadly similar to those for turbidity. Figure 2 shows that aeration (oxygenation) caused a substantial decrease in the 99.9 per cent inactivation time for faecal coliforms in illuminated water at the lowest levels of humic acids (colour), but this beneficial effect decreased as the colour increased. The influence of oxygen was minimal at 10 mg/litre humic acids, with an inactivation time for the aerobic treatment only slightly lower than that for the anaerobic water sample.

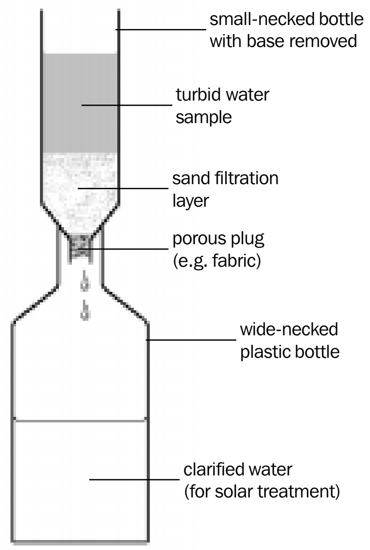


Figure 3. Simple small-scale filtration system

Discussion and conclusions

Taken together, the results shown here suggest that solar photo-oxidation may be severely impaired under those field conditions where the water has a high level of colour and/or turbidity. One method of reducing the amount of particulate material would be to carry out small-scale rapid sand filtration of the water before it is exposed to sunlight. Figure 3 shows how such a system might operate, using a second, smaller-necked plastic bottle, creating a sand filtration layer to clarify the water as it runs into the wider-necked plastic bottle. While such a filtration system will remove a proportion of the contaminating microbes, its main purpose would be to reduce the turbidity and/or colour of the water to a level where subsequent solar photo-oxidation will function effectively.

For such waters, the treatment process would involve three major stages:

1. CLARIFICATION - either by rapid filtration, or by coagulation (e.g. using *Moringa*).
2. AERATION (OXYGENATION) - by occasional, vigorous mixing before and during treatment.
3. ILLUMINATION - in full sunlight, for as long as possible.

The preliminary results of field work in Rajasthan will be discussed in the presentation.

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