

SOLAR DISINFECTION OF WATER FOR RURAL COMMUNITIES

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ABSTRACT

Surveys on water sources and use, as well as on the availability of containers in rural areas were conducted.

Naturally and artificially contaminated water samples were exposed to solar radiation in different containers, varying in material, colour and shape, and their bacteriological load was tested as a function of time of solar exposure. The optical properties of the containers were also studied, in order to determine the most suitable type of container, which will serve for the solar disinfection of water. The most lethal region of the solar spectrum, responsible for the germicidal effect of bacteria contaminating the water was also studied.

It was found that contaminated water becomes perfectly fit for human consumption after being exposed to sunrays for 2 to 4 hours depending on the type, shape and colour of the container. The most lethal range of the spectrum for the germicidal effect was that in the near UV region (350-500 nm).

INTRODUCTION

Water is essential for life. But water contaminated with disease causing organisms can be just as deadly as no water at all. In rural areas of the developing countries, most people have no access to a safe water supply nor adequate sanitation facilities. Many household wastes, agricultural wastes, community refuse and sewage are disposed directly into water bodies used for drinking, bathing, laundry and food preparation (Okoronkwo and Odeyemi, 1984; Petters and Odeyemi, 1985). As a matter of fact, 80% of sickness in developing countries is caused by water-borne and water-washed diseases, 60% of whom are children (Anon, 1986). In Egypt, one out of ten newborn children is destined to pass away before reaching the age of four, because of these diseases (Khalil, 1981).

An examination of water quality is basically a determination of the organisms as well as the mineral and organic compounds contained in the water. However, the most important parameter of drinking water quality is its bacteriological quality, i.e. its content of bacteria and viruses (Feachem et al, 1980). It is not practicable to test the water for all organisms that it might possibly contain. Instead, the water is examined for specific types of bacteria, which originate, in large numbers, from human and animal excreta and whose presence in the water is indicative of faecal contamination. Biological pollution of the water through faecal contamination is a basic cause of morbidity due to water-borne diseases which rank first among all other diseases in developing countries (Okoronkwo and Odeyemi, 1984).

radiation. When the incident artificial radiation was filtered, so as to allow only certain wavelengths to be incident on the water sample, the bacterial diminution varied. These experiments showed that the near ultraviolet region (350 to 500 nm) is the most lethal region of the spectrum responsible for the germicidal action. The same was confirmed by exposing water to direct sunlight in coloured containers, as shown in Figure 3, the colour of each container depends on the colorant or impurity element, present in the bottle material (Cotis, 1986).

Artificially infected water with E. coli, Staphylococcus, Pseudomonas aeruginosa and Klebsiella pneumoniae, exhibited similar results when exposed to direct sunrays and room lighting.

Solar disinfected water was re-tested after one week storage in room conditions, as well as in complete darkness, and it was found pure.

SUMMARY AND CONCLUSIONS

The feasibility of the water disinfection by exposure to solar radiation was found to depend on three factors: the container used; the energy of the radiation transmitted through the container; the type of micro-organism present in the water.

The results indicate that although the intensity of the light transmitted to the water was the same for containers which transmit light in the near UV region, and those in the near IR region, their bactericidal effects were totally different. The highest degree of decontamination was achieved by containers transmitting in the near UV region of the spectrum. This leads to the conclusion that the bactericidal effect is accounted for by the wavelength, hence the energy, and not the intensity of the transmitted radiation. The most lethal range of the spectrum responsible for the germicidal effect was found to be the near UV (350 to 500 nm). The rise in the water temperature did not seem to play as an active role in the water decontamination process as the sunlight (Figure 4).

Regions having about 300 sunny days with clear skies per year, like Egypt, are naturally best suited for the utilization of solar energy for the disinfection of drinking water, as well as other applications. Cloud formation does not present serious problems throughout the greater part of the year. Clouds reduce the intensity of direct sunlight by scattering the sunrays, producing diffuse daylight. Diffuse daylight can exhibit bactericidal action, but at a slower rate. Therefore, during cloudy days it will be necessary to prolong the exposure period.

Further research work is needed in order to study the feasibility of the method on other micro-organisms specially on the Bilharzia, Cercaria and Cholera vibrio present in water, with the hope that it will serve as a useful guide for primary health care workers involved in the control of water-borne diseases.

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TABLE 1 RESULTS OBTAINED FROM THE SURVEY OF WATER RESOURCES IN THE VILLAGE OF BASAISA, EGYPT.

Source No.	Depth (m)	Bacterial content (ml)	Preference for use
2 Well	31	40×10^4	It is used by six neighbouring communities for all purposes.
6 Well	16	5.5×10^4	Used by 3/4 of the village for all purposes
8 Well	33	980×10^4	Used by 1/5 of the village for all purposes
9 Well	17	22×10^4	Used by most of the animals of the village due to its location in the fields
12 Well	32	2.1×10^4	The mosque well, used by all people
A Canal	0.5	30×10^4	Used by women for washing clothes and utensils, and by animals for drinking
B Stream	0.5	95×10^4	Similar to source A
C Stream	2.0	1.0×10^4	Used by men for swimming

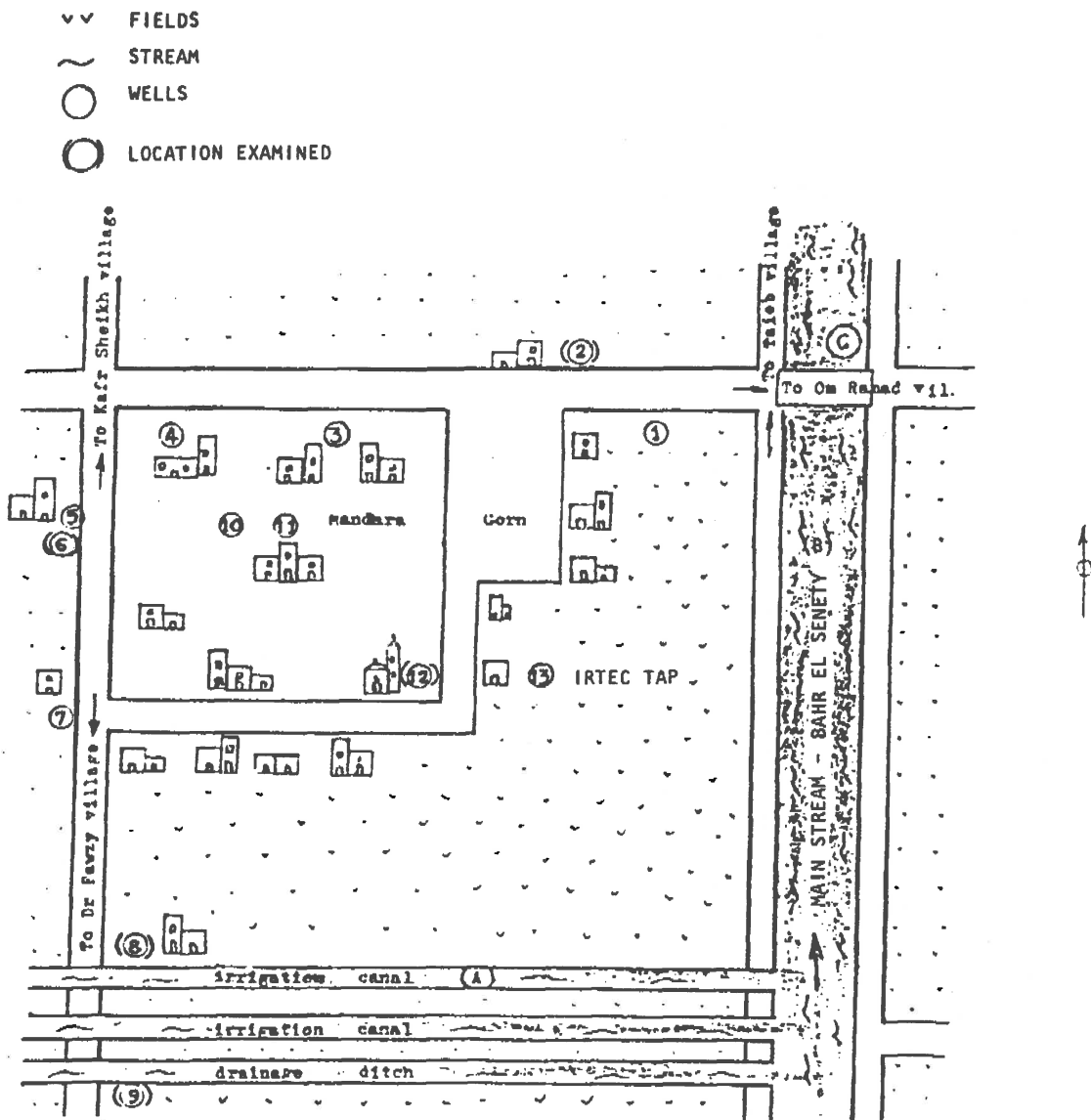


FIGURE 1. LOCATIONS EXAMINED FOR WATER CONTAMINATION IN THE VILLAGE OF BASAISA, 15 KM N.W. OF ZAGAZIG, EL-SHARKIYA GOVERNORATE, EGYPT

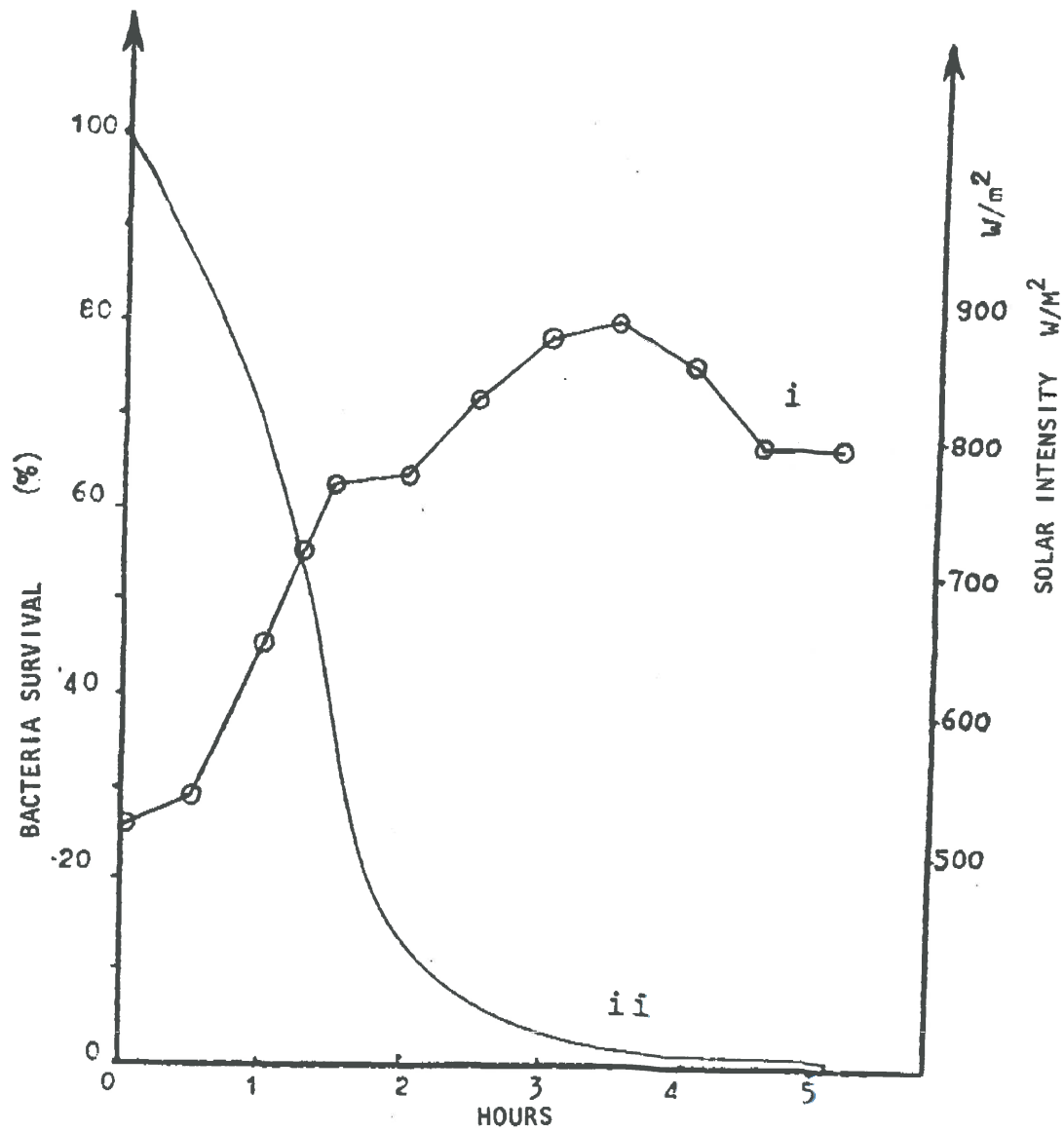


FIGURE 3. DESTRUCTION OF BACTERIA UPON EXPOSURE TO SUN
 SOURCE NO. 8, CONTAINER: BLUISH PLASTIC
 DATE: 14 JANUARY 1986
 i. SOLAR INTENSITY
 ii. BACTERIAL SURVIVAL

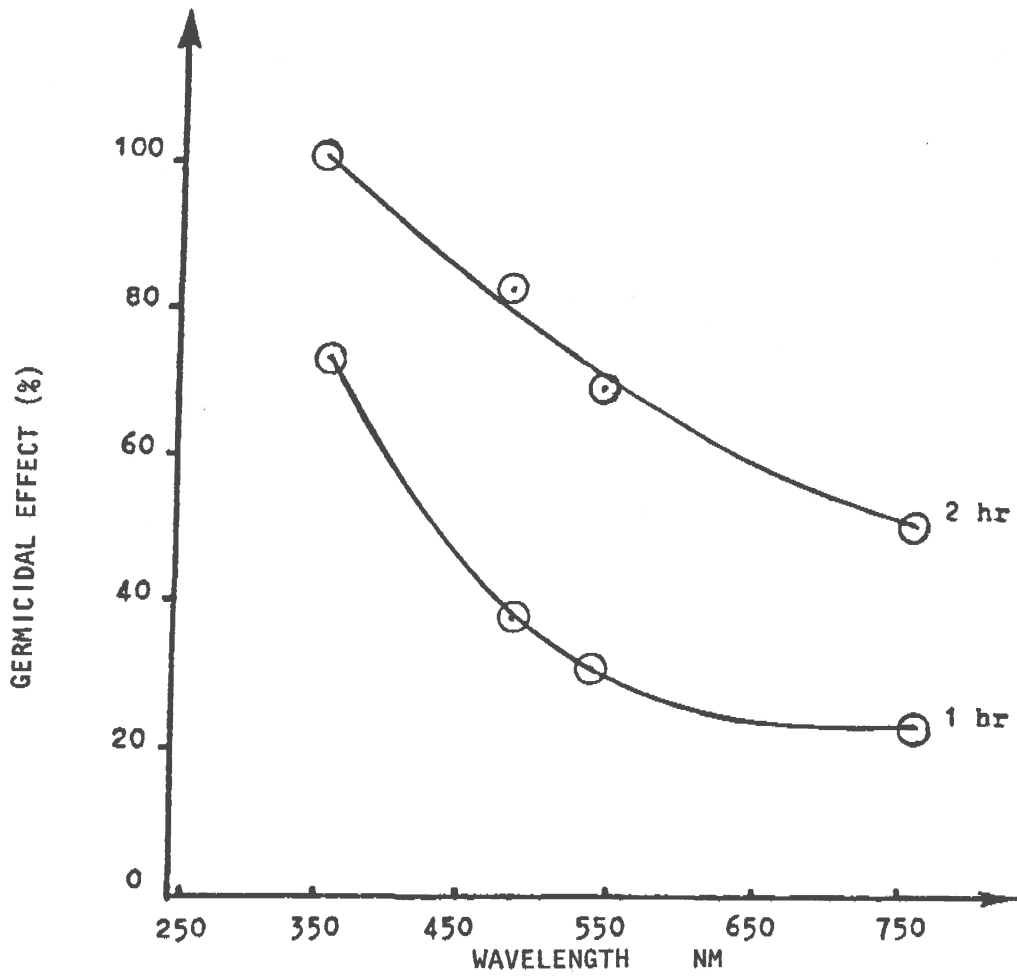


FIGURE 5. ACTION SPECTRUM SHOWING THE RELATIVE GERMICIDAL EFFECT OF TUNGSTEN LAMP ON TOTAL BACTERIAL COUNT AS A FUNCTION OF WAVELENGTH

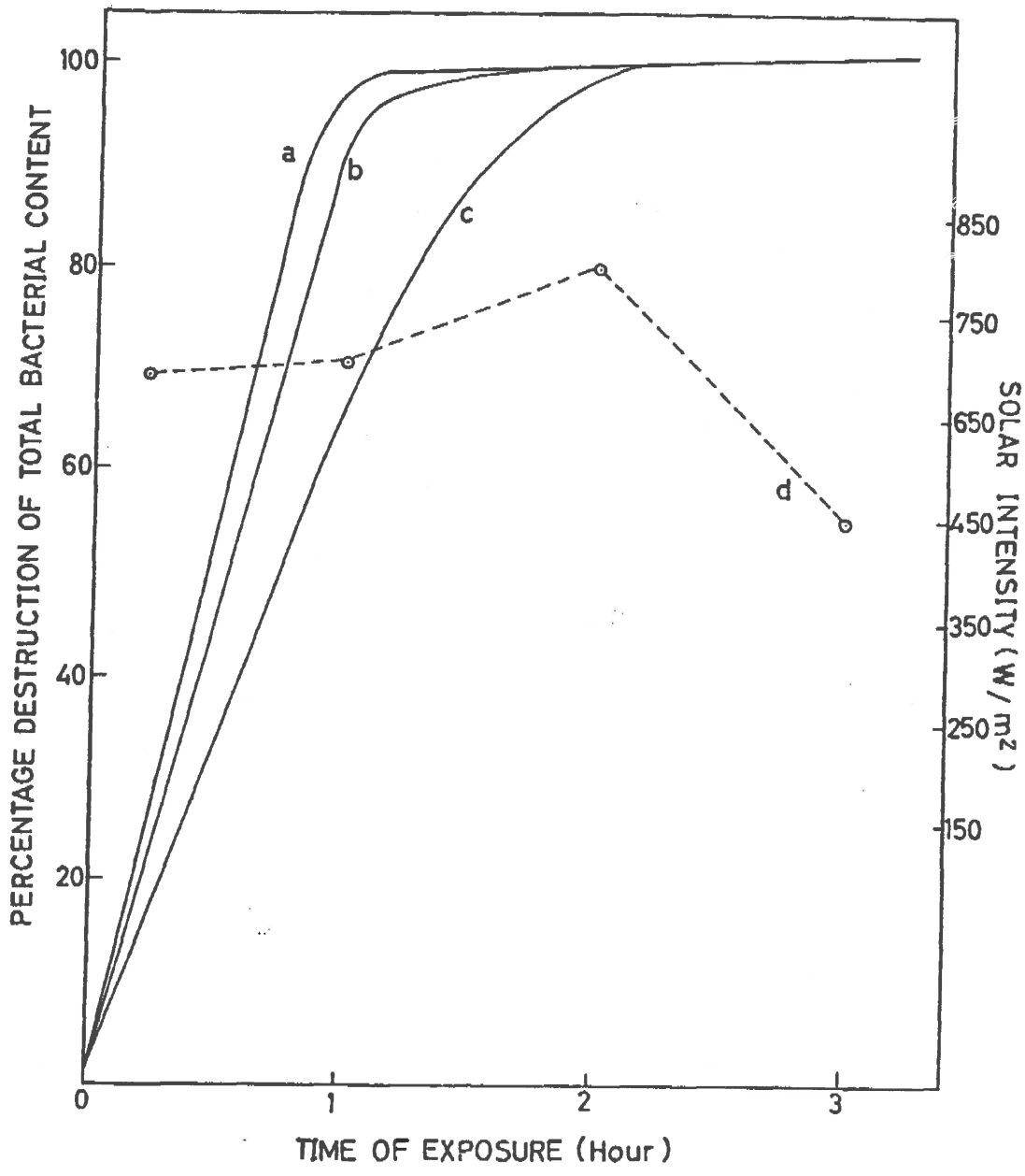


Fig. 7 Fate of TBC of artificially contaminated water with:
 (a) *Staphylococcus aureus*
 (b) *Pseudomonas aeruginosa*
 (c) *Klebsiella pneumoniae*

The dashed curve shows the solar intensity in w/m^2 at time of exposure.