SOLAIR disinfection of coliform bacteria in hand-drawn drinking water

V Meyer[1]* and RH Reed[2]

[1]*Technikon Northern Gauteng, Department of Chemistry, Private Bag X07, Pretoria North 0116, South Africa*

[2]*Division of Biomedical Sciences, Department of Chemical & Life Sciences, University of Northumbria at Newcastle, Newcastle upon Tyne, NE1 9ST, United Kingdom.*

Abstract

SOLAIR is an alternative disinfection method utilising natural sunlight (specifically UV-A and UV-B radiation) and oxygen (from atmospheric air) to damage, inactivate and/or kill the coliform bacteria found in contaminated water. It is a natural process (virtually self-purification) with no need to add any potentially hazardous chemicals or to use sophisticated and expensive equipment.

The SOLAIR process was applied in a typical South African scenario, i.e., a rural informal village where water for domestic use is drawn from an unlined and heavily contaminated well. Results obtained showed significant reduction (99.99%) in both the faecal and total coliform counts within 4 to 6 h, with no subsequent reactivation of growth after 24 h. The disinfected water complied in terms of bacteriological quality, with both the South African Bureau of Standards (SABS), drinking water standards and the South African Water Quality Guidelines (SAWQG) for domestic use as prescribed by the Department of Water Affairs and Forestry (DWAF). The rate of bacterial reduction depended on various parameters including the type and colour of plastic containers used, the initial concentration of micro-organisms in the drawn water, the irradiation levels of UV-A and UV-B rays, the oxygen concentration and distribution in the water containers, and the presence of visible turbidity.

In South Africa where more than 8 m. people are still using water obtained directly from alternative sources such as rivers, streams, boreholes, wells, community taps and dams, SOLAIR could prove to be an efficient and an economically feasible method to be used for disinfection of hand-drawn water to an acceptable potable standard.

Introduction

Disinfection of water is an essential unit process required to destroy pathogenic micro-organisms resulting in a potable water which is safe for human consumption. Disinfected potable water reduces the occurrence of water-borne diseases and the high incidence of mortality of infants and the elderly (Genthe and Du Preez, 1995; Genthe and Seager, 1996).

However, disinfection in rural, poverty-stricken areas with no running water, remains a huge problem (Genthe and Seager, 1996). Various uncomplicated methods of disinfection have been in place for some time, but most of these methods require some form of infrastructure, economic investment and educated or informed use (Solsona, 1996). These methods include filtration, coagulation, chlorination, and oxidation. Boiling and aeration have also been used with limited application (small volumes) and with sometimes unreliable results (Solsona, 1996).

Disinfection using solar radiation (sunlight), which rendered faecal bacteria inactive by thermal radiation in high turbidity waters, has been applied for centuries (Joyce et al., 1996). A water temperature of more than 55°C was needed to obtain good faecal bacterial cell inactivation. Wegelin et al. (1994), Wegelin and Sommer (1996) and Sommer et al. (1997) developed the SODIS (solar water disinfection) and SOPAS (solar pasteurisation) processes which rely on the synergistic effects of solar radiation and thermal water treatment.

The advantages of using solar radiation are numerous and include: no dangerous, toxic, or hazardous by-products are produced; no smell and/or taste are imparted to the water; it is economical and is easy and simple to apply. The ultraviolet (UV) component of sunlight is, however, filtered out by ozone for example, water droplets, and smoke, so that the UV light which actually reaches the earth's surface is restricted to a wavelength range of between 295 and 400 nm. This limits the microbiocidal properties of solar radiation as a sole disinfectant.

Reed (1996 and 1997a) investigated the role of fresh air (containing oxygen and other gases in variable concentrations) in the efficiency of solar disinfection processes. The toxicity of oxygen as a disinfectant is due to the superoxide and hydroxyl radicals formed during oxidation reactions. These radicals are very reactive but short-lived, limiting their disinfection efficiency. Results recorded indicated that some faecal bacterial species have a resistance to radiation inactivation in the absence of oxygen. The research led to the development of a process called solar photo-oxidative disinfection or SOLAIR.

SOLAIR combines the use of solar (UV) radiation and oxygen from the natural environment in an alternative disinfection method with a higher microbiocidal efficiency than the two disinfectants separately (Reed, 1996 and 1997a,b,c). This method is, in effect, a natural process (self-purification) without the addition of any potentially hazardous chemicals or a need for sophisticated and/or expensive equipment.

The following represents results from a full-scale field application of the SOLAIR disinfection method on hand-drawn drinking water in a typical rural and poverty-stricken scenario.

Materials and methods

Source of hand-drawn water

Water was abstracted from an unprotected well in the Bridgeview Mandela Village near Hammanskraal, Pretoria. The water from the

* To whom all correspondence should be addressed.

☎(012) 799 9098; fax(012) 7999022; e-mail: vermey@mweb.co.za

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