



**THE FEASIBILITY OF SOLAR PHOTO-
OXIDATIVE DISINFECTION ON HAND DRAWN
DRINKING WATER IN THE SOUTH AFRICAN
RURAL SCENARIO**

by

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ABSTRACT

Background

Solar photo-oxidation is a simple disinfection method which is easily applied, reliable, and needs little supervision and economical investment. The method makes use of ultraviolet radiation from the sun (specifically UV-A and UV-B radiation) and oxygen from the atmosphere. It is a natural process (virtually “selfpurification”) without addition of any potentially hazardous chemicals or a need for any sophisticated and expensive equipment.

In South Africa where eight million people are still without running water and where most of these people use water from alternative sources such as dams, rivers, and streams, the solar photo-oxidation process could prove to be an effective and economical viable disinfection method for application in especially rural communities. This will ensure clean and microbiological “safe” water to water users in these communities.

Objectives

The main objectives of the research project are:

- Determine the feasibility and the applicability of the solar photo-oxidation process as an alternative and economical method of disinfection of hand drawn drinking water in the South African rural scenario.
- Observe the effects of various selected physical and chemical parameters on the disinfection efficiency of the solar photo-oxidation process. The parameters chosen from the literature are: cloud cover; turbidity; colour of plastic

containers; the volume of water; and the seasonal changes in oxygen transfer efficiency and ultraviolet radiation intensity.

Summary of major results and conclusions

The solar photo-oxidation process proved to be an effective and economical disinfection process. The results also showed that the faecal coliform bacteria are irreversibly inactivated by the synergistic effect of solar radiation and oxygen in a relative short period of time. This disinfection process resulted in water with a zero faecal coliform (FC) count within a period of three to five hours, depending on the initial concentration of bacteria within the contaminated hand drawn water and the total volume of water being disinfected. The process was not drastically affected by the changing seasons, but was affected increasingly by visible turbidity, low concentrations of oxygen; the colour of water containers used, and heavy dense cloud cover.

The solar photo-oxidation process does not require a big capital investment and needs very little operational or educational skills and can thus be recommended as an alternative simple process to be used in South African rural and poor communities where running water is not readily available.

The following major conclusions were drawn:

- The process is effective on smaller volumes of water - 2 to 25 litres. This is enough water for daily use on household level.
- The water containers should be filled as early in the morning as possible and exposed to sunlight from 8:00 to 15:00, when the radiation intensity is high. The water containers must be left in direct sunlight at all times and care must be taken to keep the containers out of the shadows from walls, trees, or other containers. Intermittent vigorous shaking is important to dissolve and saturate the oxygen from the atmosphere throughout the total volume of water in the

container. This will also serve to keep the microbial cells in suspension in the volume of water and increase the chance of the cells to come in contact with the penetrated and absorbed ultraviolet radiation.

- A minimum period of three to five hours is required for effective disinfection, i.e. so that the water complies with the South African Bureau of Standards (SABS) domestic water quality standards and the Department of Water Affairs and Forestry (DWAF) target water guidelines for faecal coliform (FC) concentrations in drinking water. The length of exposure time will depend on the initial concentration of FC present, the minimum DO concentration, the volume of water being disinfected, the colour of water containers used, and the turbidity of the water.
- Although high turbidity did not influence the efficiency of the disinfection significantly, it will be advisable to remove any visible turbidity before the disinfection process is applied. This will not only serve to enhance the efficiency of the process by reducing the exposure time, but also make the water more aesthetically acceptable for human consumption.
- The suitable colour and type of water container to use will be transparent or white and made from polyethylene terephthalate (PET) plastic. This type of plastic will last longer and will be damaged slower by the radiation from the sun.
- Transmission or diffusion of dissolved oxygen (DO) does not occur at significant levels through the container mouth openings. It is therefore recommended that the containers should be kept closed to prevent any contamination with dust, animal droppings and/or leaves.
- Education of end users will be essential for the successful use of the solar photo-oxidative disinfection process. It is especially important to instill in users

that the disinfection process does not leave any residual disinfection capacity after the disinfection is over, and that good hygienic practices will be essential in prevention or minimization of secondary pollution or contamination of the disinfected water.

Publications and presentations

Two full length publications in accredited journals: one national journal (*Water SA*) and one international journal (*Letters in Applied Microbiology*)

Two posters presented at national conferences (Interscience '98 and WISA 2000)

Report to the Water Research Commission (WRC), Report K8/299/98 (in print).

EKSERP

Agtergrond

Foto-oksidasië is 'n eenvoudige ontsmettings metode wat maklik toegepas kan word en wat min toesig en lae ekonomiese uitleg benodig. Die metode is afhanklik van die gekombineerde aanslag wat ultraviolet bestraling vanaf die son (spesifiek UV-A en UV-B) en suurstof vanaf die atmosfeer, op die mikrobiese selle het. Dit is 'n natuurlike proses wat geen byvoeging van enige potensieële giftige chemikalië of gesofistikeerde en duur masjinerie benodig nie.

In Suid Afrika, waar agt miljoen mense nog steeds sonder lopende water is en waar meeste van die mense hulle water vanaf alternatiewe bronne soos damme, riviere en strome verkry, kan foto-oksidasië 'n effektiewe en ekonomiese vatbare ontsmettings metode wees om toe te pas in veral onderontwikkelende en landelike gemeenskappe. Dit kan water wat mikrobiologies "veilig" is, verskaf aan die genoemde gemeenskappe.

Doelwitte

Die hoof doelwitte van die navorsing is:

- Ondersoek die moontlikheid en toepaslikheid van die foto-oksidasië proses as 'n alternatiewe en ekonomiese metode vir ontsmetting van water wat met die hand getrek word in the onderontwikkelende en landelike Suid Afrikaanse gemeenskappe.
- Ondersoek die effek van die geselekteerde fisiese en chemiese parameters op die ontsmettings effektiwiteit van die foto-oksidasië proses.

- Die parameters sluit in: swaar en digte wolk bedekking; troebelheid; verskillende volume water; die kleur van die plastiese water houers in gebruik; die variasies in suurstof oordrag en ultraviolet bestralings intensiteite gedurende die verskillende seisoene (lente, somer, herfs en winter).

Opsomming van resultate en gevolgtrekkings

Resultate verkry het bewys dat foto-oksidasië 'n effektiewe en ekonomiese ontsmetting proses is. Die resultate bewys dat fekale kolivormige bakterieë word onomkeerbaar geïnaktiveer deur die sinergistiese effek van ultraviolet bestraling en suurstof in 'n relatiewe kort tyd. Die ontsmettings-proses lewer water met zero fekale kolivorm (FK) telling binne 'n bestek van drie tot vyf uur, afhangend van die oorspronklike konsentrasie van bakterieë in die gekontaminateerde hand-getrekte water en die volume water wat ontsmet word. Die proses word nie drasties geïmpak deur die veranderde seisoene nie, maar was wel geïmpak deur verhoogde troebelheid, lae konsentrasies opgeloste suurstof en swaar en digte wolk bedekking.

Die foto-oksidasië proses het nie groot kapitale investering nodig nie en benodig ook baie min operasionele bekwaamheid en kan dus voorgestel word as 'n alternatiewe metode om te gebruik in onderontwikkelende en landelike gebiede waar lopende water nie vrylik beskikbaar is nie.

Die volgende gevolgtrekkings kan gemaak word:

- Die proses was effektief op kleiner volumes water - 2 tot 25 liters. Dit is egter in meeste gevalle genoeg water vir daaglikse gebruik op huishoudelike skaal.
- Die water houers moet so vroeg moontlik in die oggend gevul word en dan aan direkte sonlig gedurende 8:00 tot 15:00, blootgestel word. Gedurende die tyd is die ultraviolet bestraling intensiteit hoog. Die houers moet ten alle tye gedurende toepassing in direkte sonlig geplaas word en daar moet voorsorg getref word om die water houers uit skaduwees afkomstig vanaf mure, bome

of ander houers van die genoemde houers te hou. Hewige geskud van die water gevulde houers is belangrik om die suurstof op te los en te meng met die totale volume water. Dit sal verder help om die mikrobiële selle in suspensie te hou en die kans dat al die selle in kontak met die deurdringende en geabsorbeerde ultraviolet bestraling en opgeloste suurstof kom, verhoog.

- 'n Minimum periode van tussen 3 tot 5 ure word benodig vir effektiewe ontsmettings, i.e. die water voldoen aan die SABS huishoudelike water kwaliteits standaard en die Departement Waterwese en Bosbou riglyne vir FK konsentrasies in drink water. Die tyd van blootstelling sal afhang van die oorspronklike konsentrasie FK, die opgeloste suurstof konsentrasie, die volume water, die kleur houer, en die troebelheid van die water.
- Alhoewel hoë troebelheid nie die effektiwiteit van ontsmettings drasties beïnvloed het nie, is dit raadsaam om enige sigbare troebelheid voor toepassing van die proses te verwyder. Dit dien nie net om die effektiwiteit van die ontsmettings proses te verhoog deur die blootstellings tyd te verlaag nie, maar ook om die water meer esteties aanvaarbaar te maak vir menslike gebruik.
- Die toepaslike kleur en tipe houer om te gebruik vir die proses is verkieslik deurskynend of wit van kleur en gemaak van poliëtileen tereftalaat (PET) plastiek. Die PET plastiek sal langer hou en stadiger deur die bestraling van die sonlig beskadig word.
- Aangesien die oordrag of difusie van suurstof nie hoofsaaklik plaas vind deur die monde van die houers nie, word dit aanbeveel om die houers toe te maak om sodoende kontaminasie deur stof, diere mis en/of blare te voorkom.
- Opleiding van die eind gebruikers is belangrik en essensieël vir die suksesvolle toepassing van die foto-oksidasie ontsmettings proses. Dit is spesifiek belangrik om dit duidelik te maak dat geen residuele ontsmettings potensiaal beskikbaar

is na oorspronklike foto-oksidatiewe ontsmetting nie en dat goeie higiene essensieël sal wees vir die voorkoming of minimalisering van sekondere kontaminasie van die gedisinfecteerde water.

Publikasies en aanbiedings

2 vol lengte publikasies in geakkrediteerde joernale: 1 nasionale joernaal (*Water SA*) en 1 internasionale joernaal (*Letters in Applied Microbiology*).

2 plakkaat aanbiedinge by die Interscience '98 en WISA 2000 konferensies.

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