

Solar Disinfection of Drinking Water

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- 1.1 Billion people without access to safe water.
- 4 Billion cases of diarrhoea (88% due to unsafe water).
- 1.8 Million die each year (majority under 5 yrs).

(data from W.H.O. 2007)

Kenya



Any intervention against waterborne disease in developing countries has to be:

Zero or Low cost

Easy to use (to boost compliance)

Sustainable

Household Water Treatment Intervention Options

- Boiling
- Filtration (ceramic, candle, sand)
- Chlorination
- Bleach
- **Solar Disinfection**

Solar disinfection technique



1992 - R.C.S.I. group started to investigate the idea that we might use sunlight and transparent bottles to make contaminated water safe to drink.





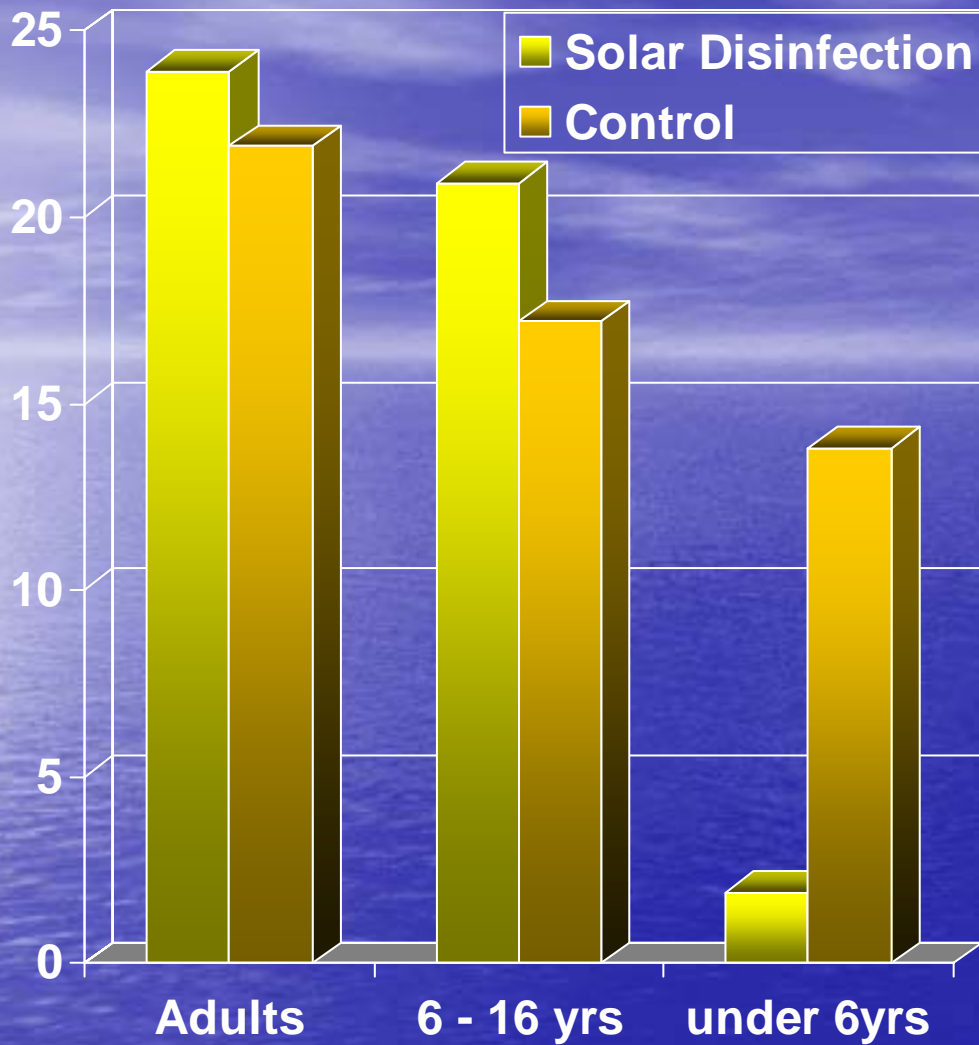
1996 Reported results
of 12-week
randomised trial
among 200 Maasai
children aged 5 to 15
years near border with
Tanzania.

10% reduction in
diarrhoea.

24% reduction in
severe diarrhoea.

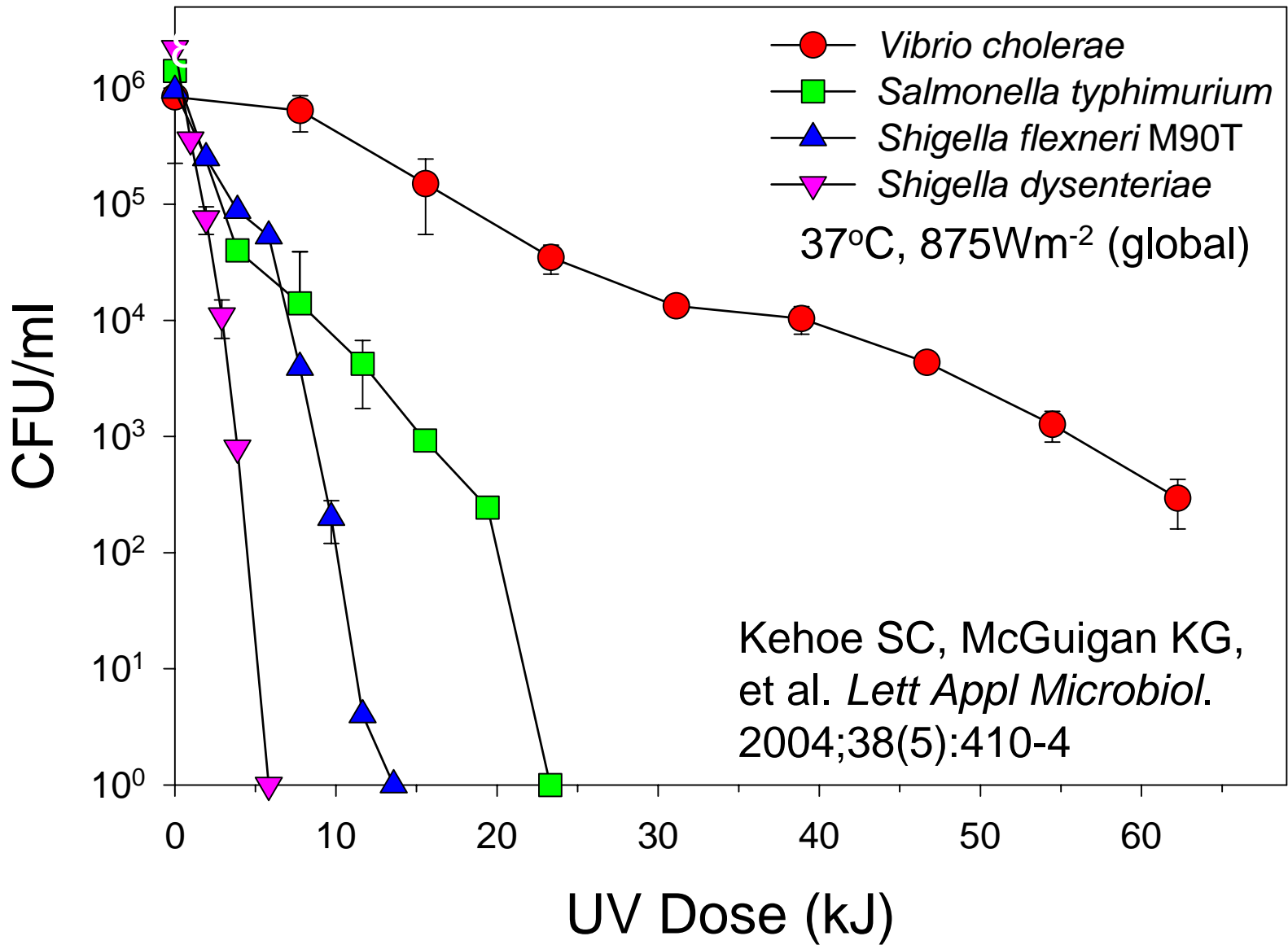
(Conroy RM, McGuigan KG, *et al.* (1996)
Lancet 348, 1695-1697)

Cholera Infection Rate (%)



Children under age 6 who used the SODIS technique were 7 times less likely than non-SODIS users to contract cholera (odds ratio = 0.12, 95% CI 0.02 to 0.65, $p = 0.014$)

Conroy RM, McGuigan KG, *et al.* (2001) *Arch. Dis. Child.* **85**, 293-295.



Mechanism of Inactivation

- Slow pasteurization of pathogens ($40 < T < 60^{\circ}\text{C}$).
- Direct and indirect UV damage to cellular molecules.
- Synergistic combination of both – elevated temperature inhibits reaction rates for repair mechanisms for damaged bio-molecules.

E. coli



Berney et al. (*Microbiology* 2006;152:1719-29) flow cytometry studies showed SODIS inactivation process for *E. coli* is:

1. ATP synthesis and efflux pump activity both cease.
2. Gradual loss of membrane potential
3. Reduction in glucose uptake
4. Cytoplasmic membrane permeable
5. Loss of culturability (last to occur)

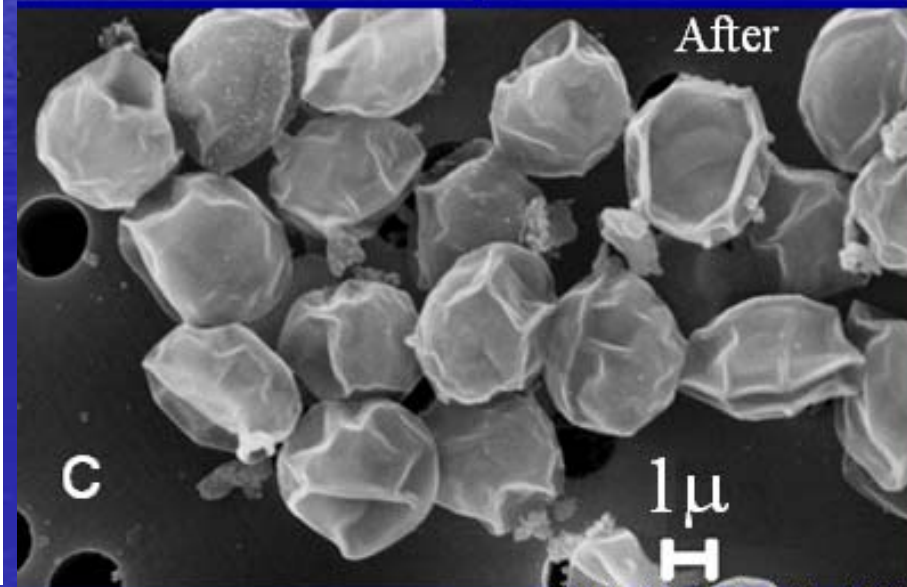
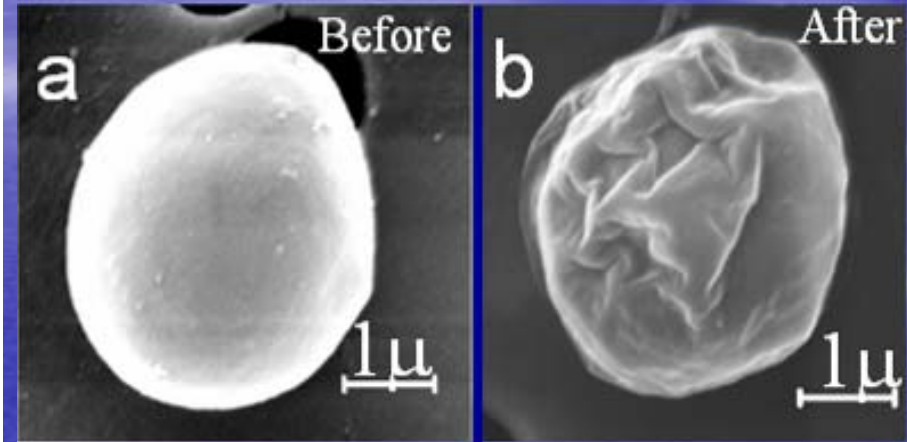
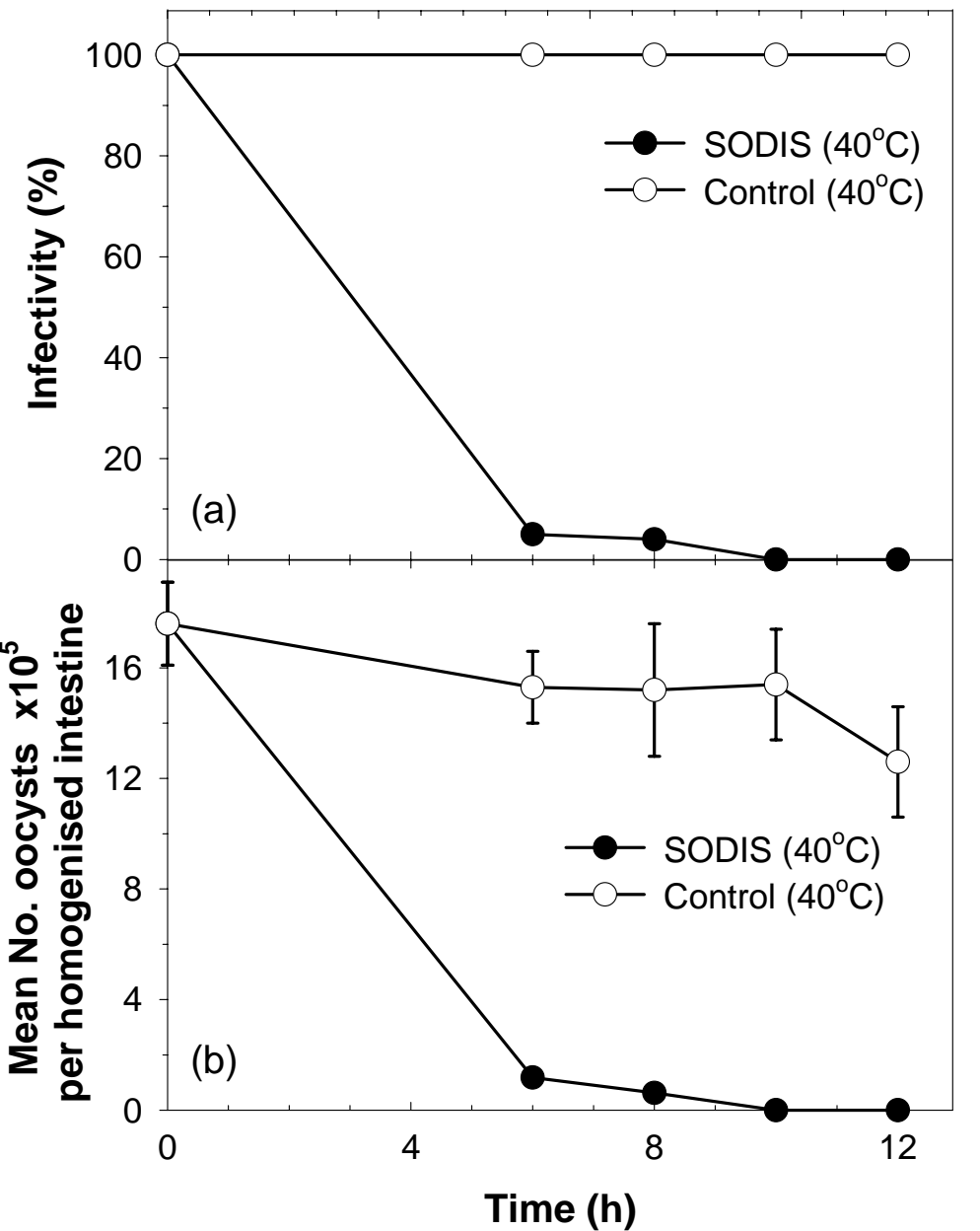
Other SODIS sensitive bacteria

<i>E. coli (EP, ET)</i>	<i>Strep. faecalis</i>
<i>Sh. dysenteriae I</i>	<i>Enterococcus sp.</i>
<i>Sh. flexneri</i>	<i>Salm. typhi</i>
<i>P. aeruginosa</i>	<i>Salm. enteritidis</i>
<i>V. cholerae</i>	<i>Salm. typhimurium</i>
<i>Y. enterocolitica</i>	<i>Camp. jejuni</i>
	<i>Staph. aureus</i>
	<i>Staph. epidermidis</i>

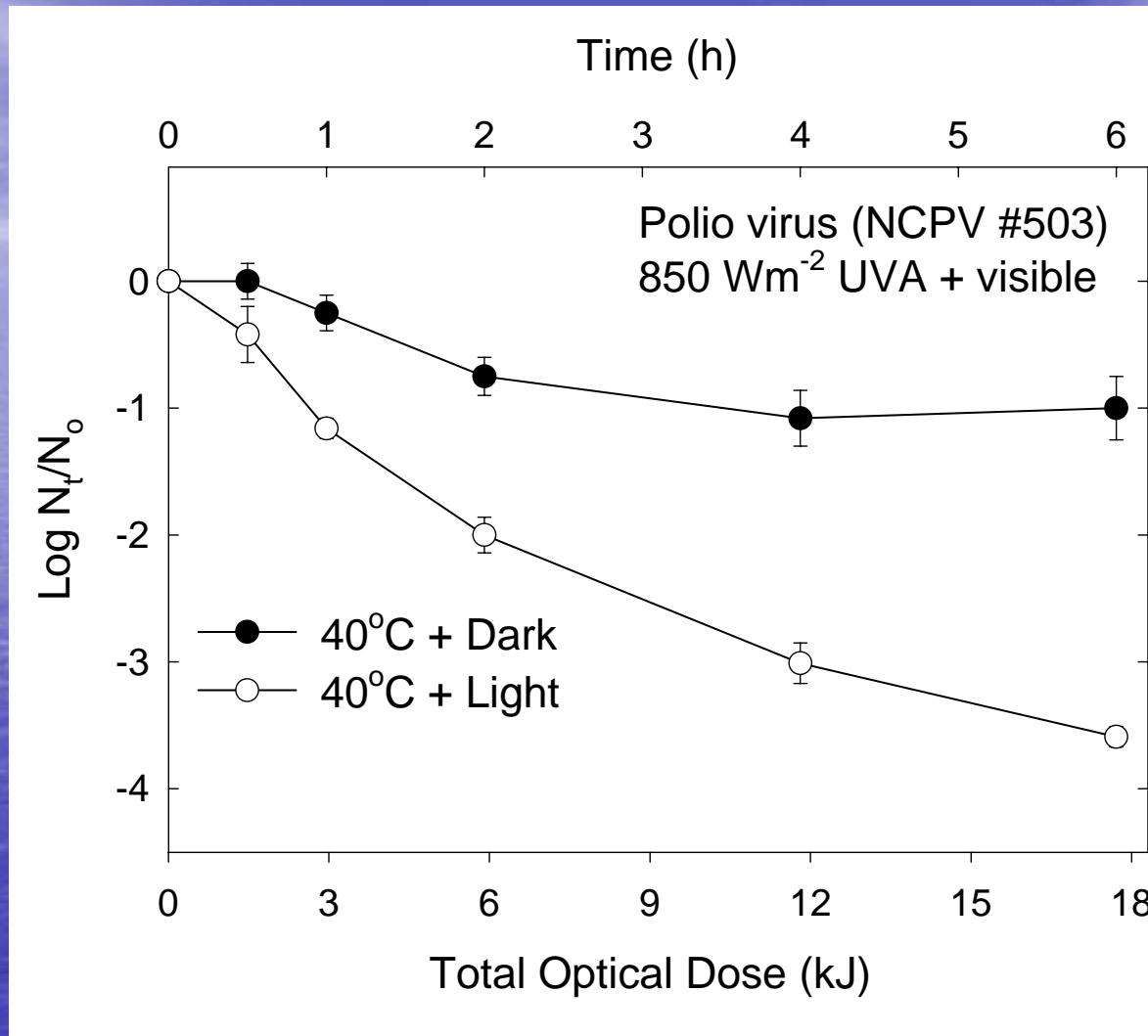
So far, we have encountered no pathogenic bacterial species that can survive 6 hours exposure to full sunlight in transparent containers smaller than 5 L.

Protozoa

Cryptosporidium parvum oocysts



Viruses: Polio virus



Heaselgrave W, McGuigan KG, *et al.* *Lett Appl. Microbiol.* 2006;43(2):125-130.

In use by more than 2 million people and in more than 28 countries around the globe



Figure 1 – Percentage of population using improved drinking water sources in 2004.



SODISWATER Project

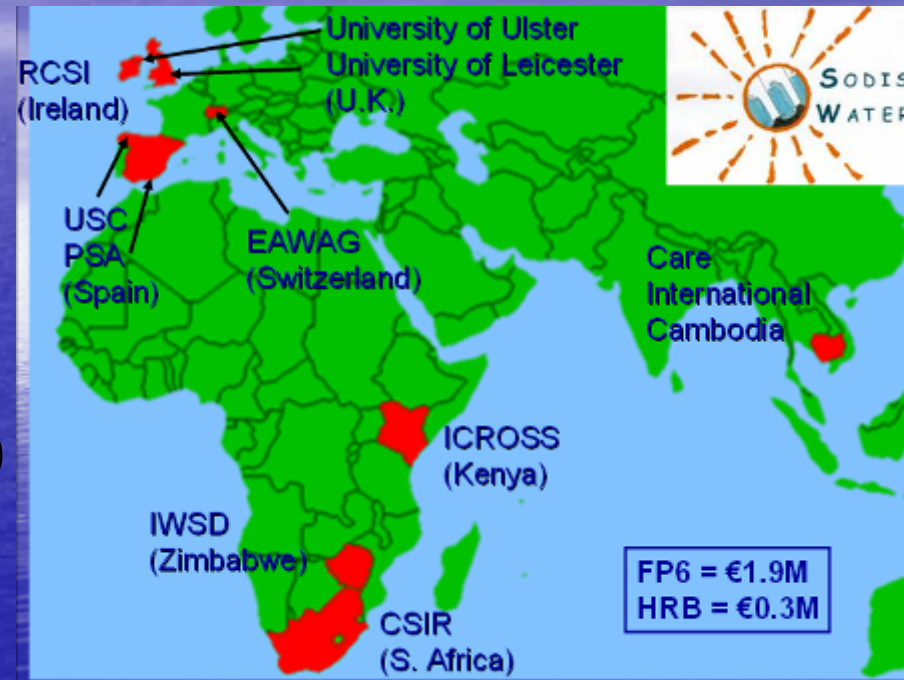
FP6–2006-INCO-CT 031650
Sept. 2006 – March 2010




- Funded by EU and Irish Govt. (€2.2 million).
- Field Studies – Cambodia, Zimbabwe, Kenya, S. Africa
- Lab Studies – Ireland, Spain, Switzerland, U.K.

Solar Disinfection of Drinking Water for Use in Developing Countries or in Emergency Situations

RCSI	(IRELAND)
UU	(UNITED KINGDOM)
CSIR	(SOUTH AFRICA)
EAWAG	(SWITZERLAND)
IWSD	(ZIMBABWE)
CIEMAT	(SPAIN)
UL	(UNITED KINGDOM)
ICROSS	(KENYA)
USC	(SPAIN)
CIC	(CAMBODIA)



Health Impact Assessments (Kenya, Zimbabwe, S. Africa, Cambodia)

 **Solar Disinfection and Child Health
Monthly Diarrhoeal Diary**

Village/Ward/Area: Mamelodi
Address: 14 Vanessa Rd
Waypoint name: M0001 Carer: Joyce
Printed: 14-May-07
Child: **Gazama**
September 2007

Household: S00001
Child: S01000

Data entered

Barcode number

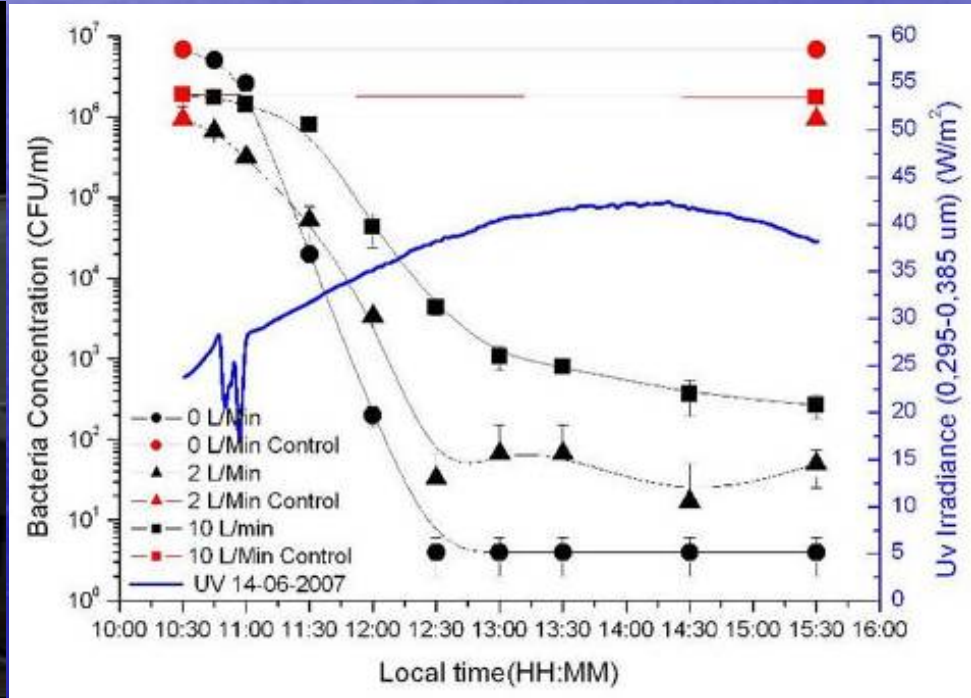
1. Tick happy face if child has no loose stools on that day
2. If child has loose stools, tick a sad face for each time he/she has it
3. If a loose stool has blood or mucus, tick the box as well

Normal stools	Loose stools	Blood Mucus	Normal stools	Loose stools	Blood Mucus	Normal stools	Loose stools	Blood Mucus
Sat 1 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Tue 11 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Fri 21 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Sun 2 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Wed 12 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Sat 22 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Mon 3 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Thu 13 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Sun 23 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Tue 4 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Fri 14 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Mon 24 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Wed 5 <input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Sat 15 <input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Tue 25 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Thu 6 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Sun 16 <input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Wed 26 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Fri 7 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Mon 17 <input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Thu 27 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Sat 8 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Tue 18 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Fri 28 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Sun 9 <input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Wed 19 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Sat 29 <input checked="" type="checkbox"/>		<input type="checkbox"/>
Mon 10 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Thu 20 <input checked="" type="checkbox"/>		<input type="checkbox"/>	Sun 30 <input checked="" type="checkbox"/>		<input type="checkbox"/>

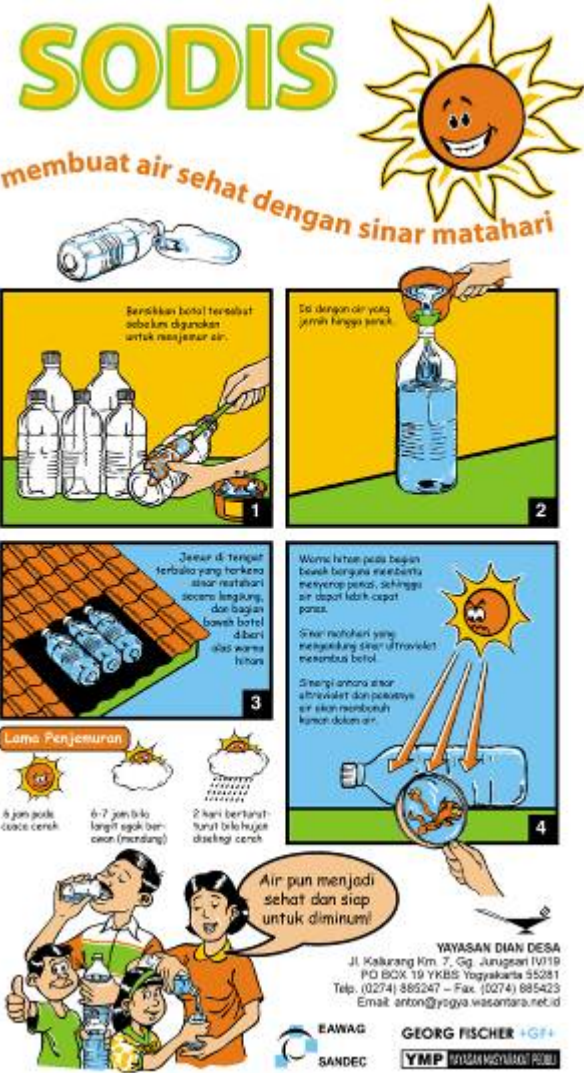
Diary number: S00001.S01000.09 Carer: Joyce(Child: Gazama) Sep 2007



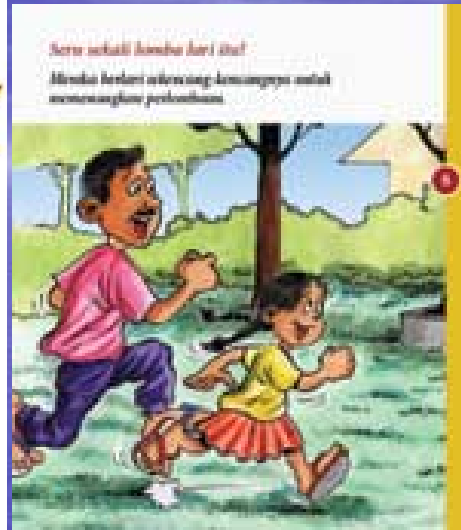
Enhancement Technologies



Dissemination/Adoption Strategies



Poster



Comic Book



Mobile Karaoke Van



Drama
(Theatre & TV)

Advantages / Disadvantages

Advantages:

- Effective.
- Cheap.
- Simple.
- Sustainable.
- No after-taste.
- Household level.

Disadvantages:

- Long term effects ???
- Not “sexy” technology.
- Requires some level of planning.
- Not effective against chemicals.
- Needs reliable sunlight.

Future Work

- Genotoxicity of photo-degradation by-products of PET bottle material.
- Assess impact of HWTS on subsequent development of the children (Anthropometric & Educational).
- Enhancement Technologies.

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