

In 1989 I emerged from my PhD studies as a young, naive & idealistic physicist with a thesis unrelated in any way to water disinfection or medicine.



Solid State Communications, Vol. 68, No. 1, pp. 7-11, 1988.
Printed in Great Britain.

0038-1098/88 \$3.00 + .00
Pergamon Press plc

A NEW PHOTOLUMINESCENCE BAND IN SILICON LIGHTLY DOPED WITH COPPER

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School of Physical Sciences, National Institute for Higher Education,
Collins Avenue, Dublin 9, Ireland

Materials Science and Engineering, B4 (1989) 269-272

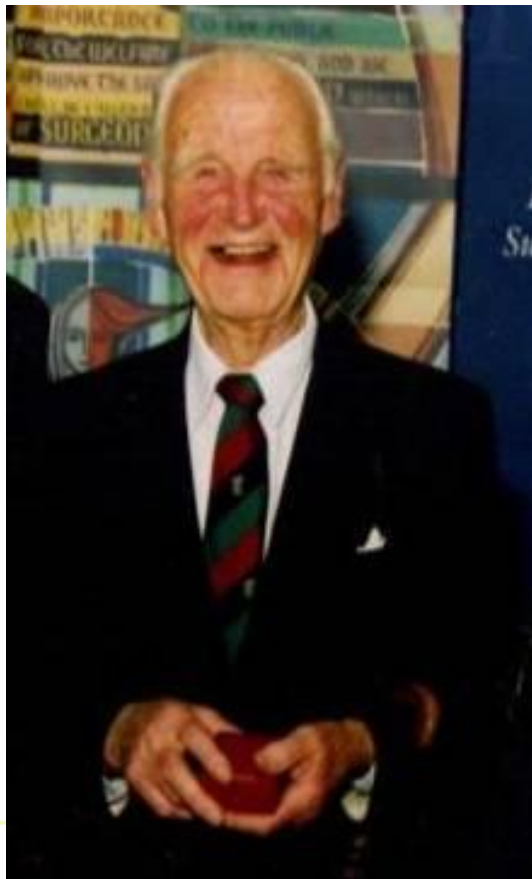
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A Uniaxial Stress Study of a Copper-related Photoluminescence Band in Silicon

K. G. MCGUIGAN and M. O. HENRY

School of Physical Sciences, Dublin City University, Collins Avenue, Dublin 9 (Ireland)

In 1992 I got a job teaching Medical Physics to medical students in the Royal College of Surgeons in Ireland Medical School



Soon after I arrived I was approached by Dr Joe Barnes, a retired lecturer in Tropical Medicine, who was interested in using empty Coca-Cola bottles to solar disinfect drinking water.





SOLAR DISINFECTION Technique

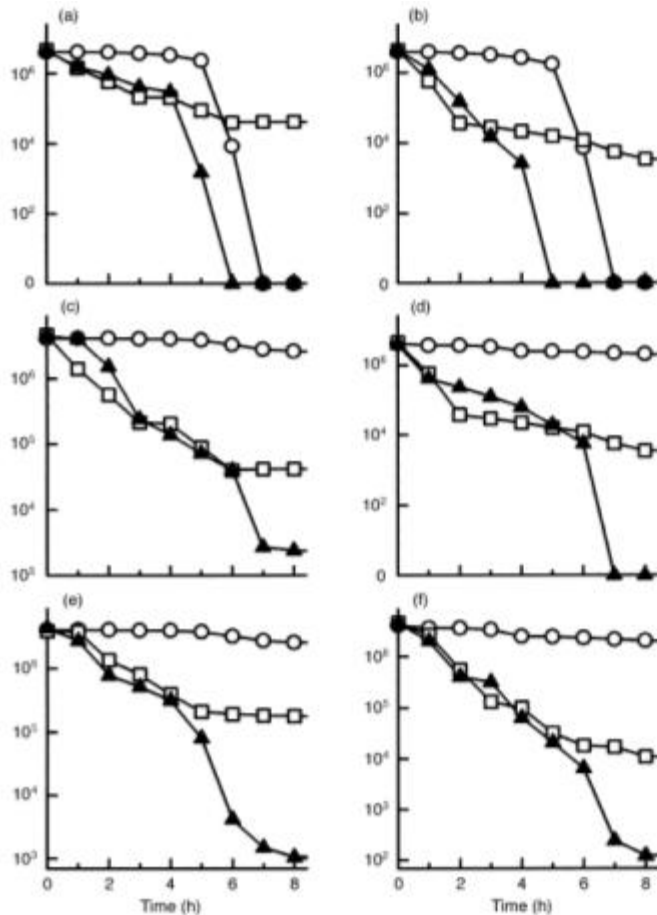


Joe Barnes wanted to know if glass/plastic bottles could be used to treat contaminated water by placing filled bottles in direct sunlight and letting solar UV kill disease causing pathogens

In 1993 I went on my first field trip to the Developing World to monitor water quality, parasite burden, typical equatorial irradiance levels, water temperatures during exposure, etc. in Southern Kenya



Armed with representative data we subsequently proved that SODIS could work in the lab.



APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Feb. 1996, p. 399-402
0099-2240/96/\$04.00+0
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Vol. 62, No. 2

Inactivation of Fecal Bacteria in Drinking Water by Solar Heating

T. M. JOYCE,¹ K. G. McGUIGAN,^{2*} M. ELMORE-MEEGAN,³ AND R. M. CONROY⁴

Journal of Applied Microbiology 1998, **84**, 1138-1148

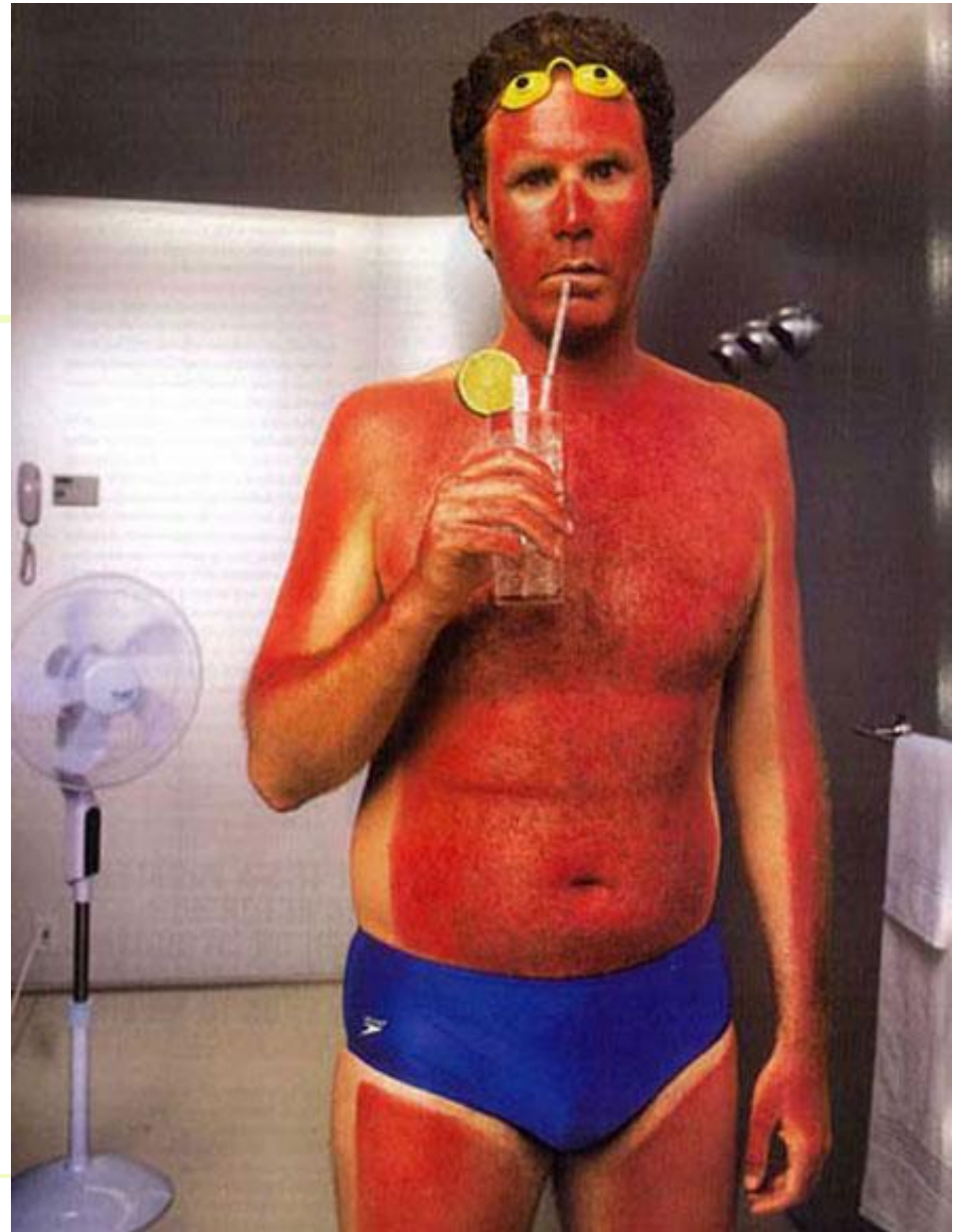
Solar disinfection of drinking water contained in transparent plastic bottles : characterizing the bacterial inactivation process

K.G. McGuigan¹, T.M. Joyce², R.M. Conroy³, J.B. Gillespie⁴ and M. Elmore-Meehan⁵

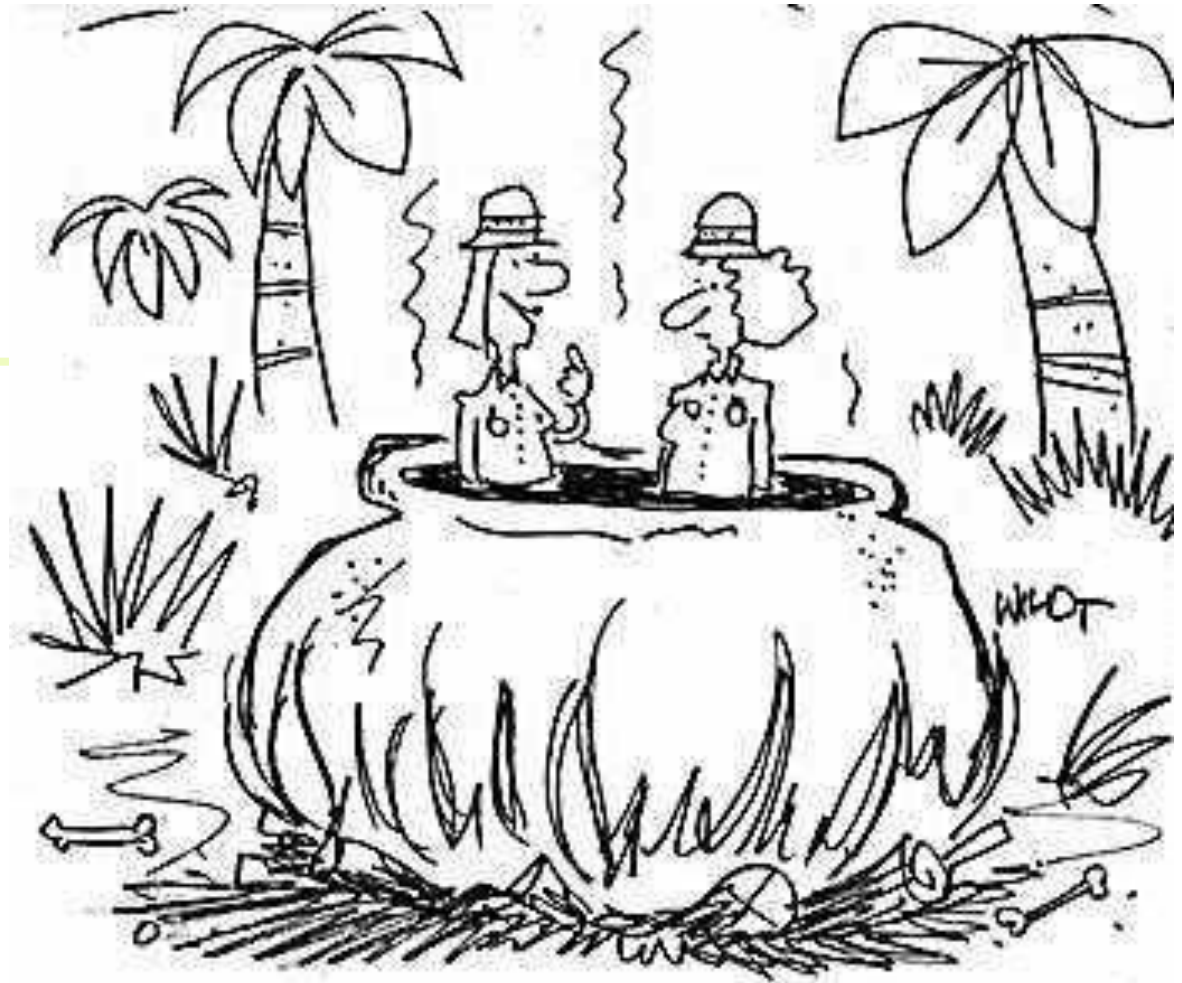
Fig. 5 Comparisons of corresponding thermal (○), optical (□) and combined (▲) bacterial inactivations achieved during simulations. Note: solid lines are not fitted. See Table 3 for simulation parameters

How does SODIS work?

Thru a synergistic combination of:
(a) Direct UV damage to the cells – similar to sunburn. Damage to cell membranes and DNA

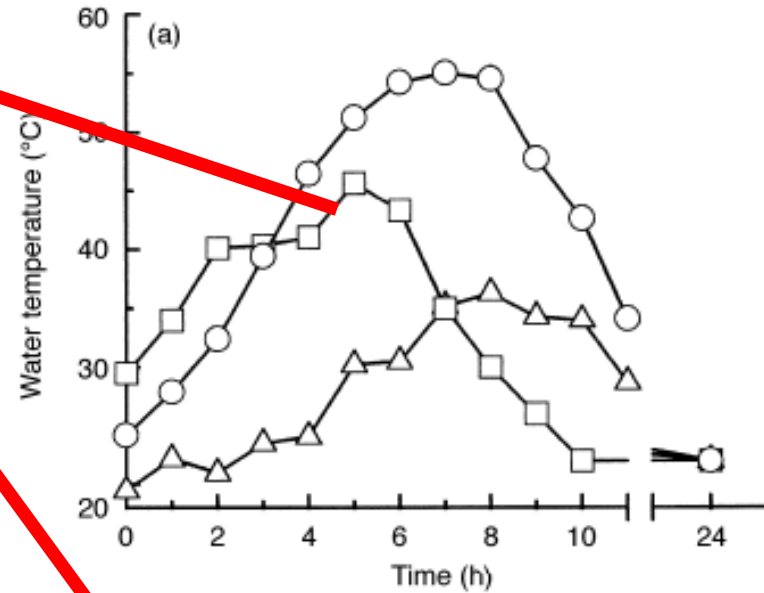
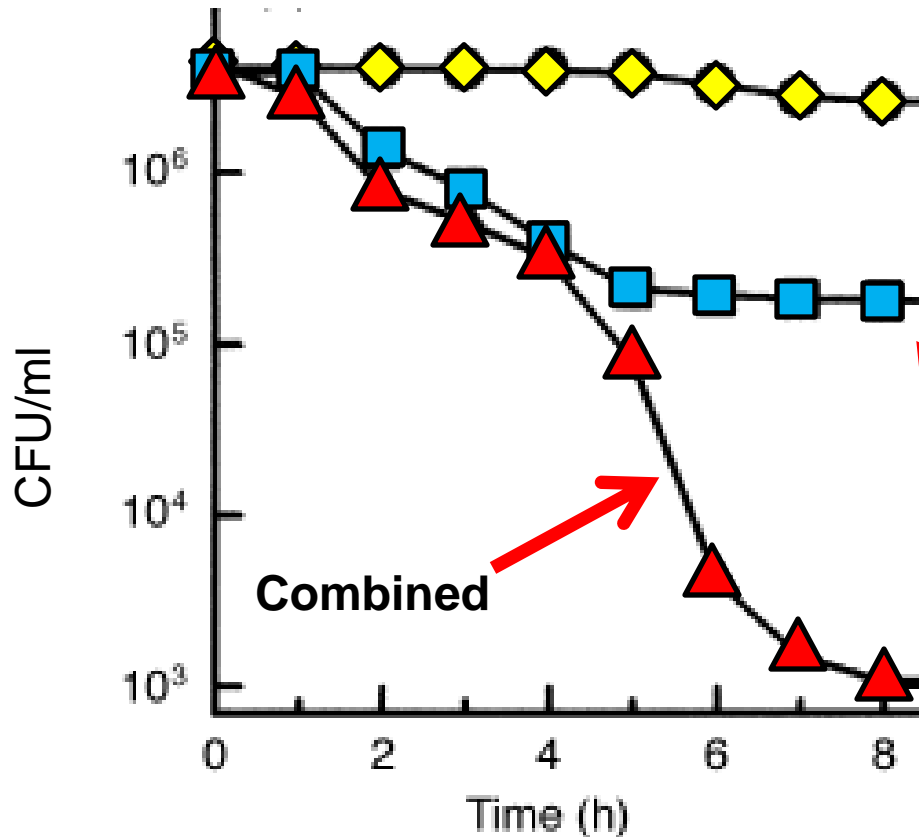


(b) Elevated water temp. denatures cellular proteins and inhibits the DNA repair mechanisms



"...but on the bright side...can't you just feel your pores opening?"

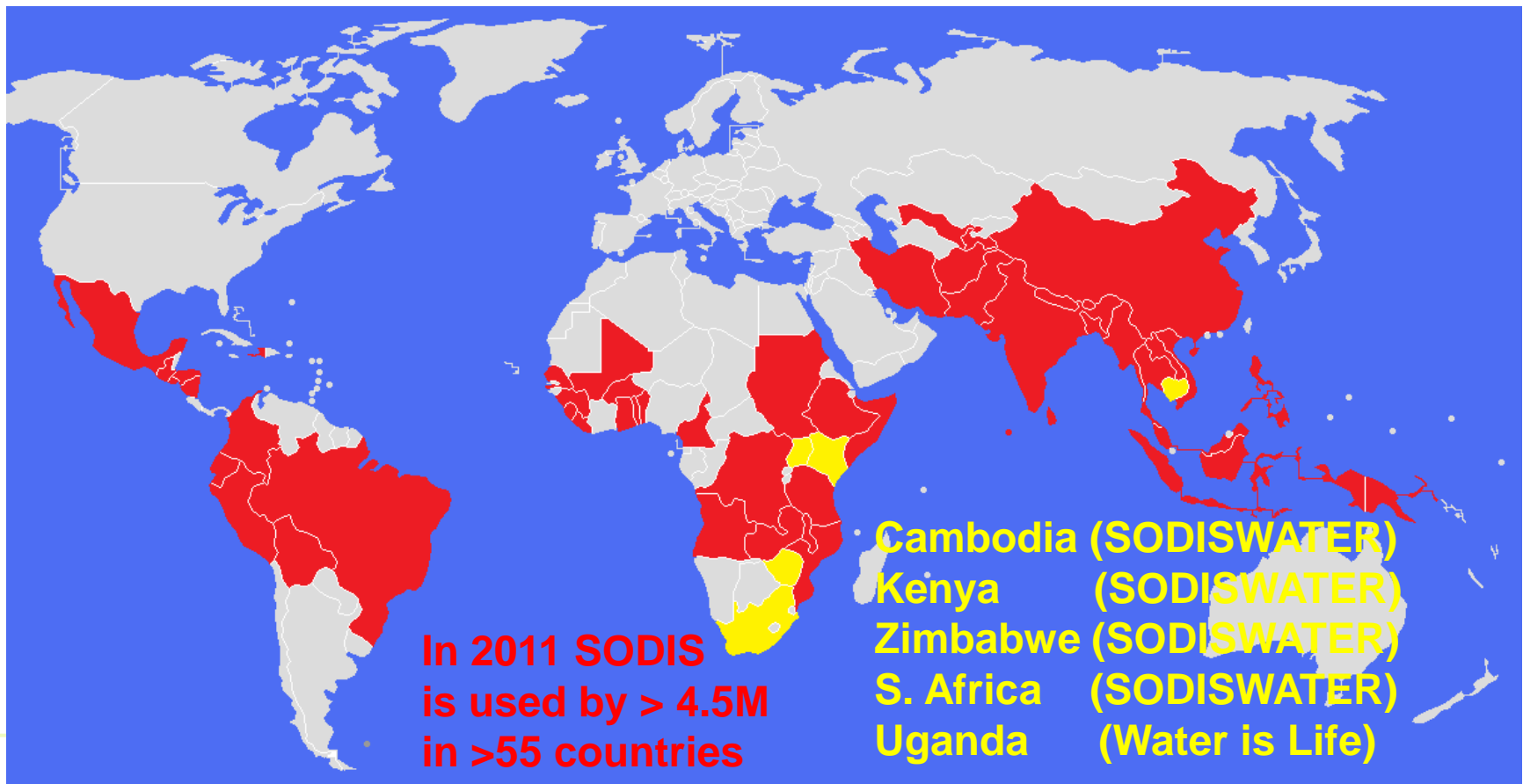
Synergistic Inactivation of *E. coli*



700 Wm⁻²

McGuigan *et al.* *Journal of Applied Microbiology* 1998;84(6):1138-1148.

Next task was to show that SODIS works in the field – Field Trials in human populations!



SODIS routine - Fetch the water





Wash the Bottle (supervised by husband)



Fill the Bottle
(supervised by cat and dog)

Expose the water in the bottle
(supervised by foreman)



After 6 hrs in the sun, drink the water
(supervised by the rest of the village)



Diarrhoeal disease rates recorded using “Smiley-Face Diary”

Solar Disinfection and Child Health Monthly Diarrhoeal Diary

Village/Ward/Area: Mamelodi
 Address: 14 Vanessa Rd
 Waypoint name: M0001 Carer: Joyce
 Filled: 14 May 07

Child: **Gazama**

Household: S00001
 Child: S01000

September 2007

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

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



First SODIS Field Study – Kenya and the Maasai Community. 12 week trial, 108 children between 5-12 years of age

- After adjustment for age, solar treatment of drinking water was associated with a reduction in all diarrhoea episodes (odds ratio 0.66 [0.50–0.87]) and in episodes of severe diarrhoea (0.65 [0.50–0.86])

THE LANCET

Early reports

Lancet 1996; **348**: 1695–97

Solar disinfection of drinking water and diarrhoea in Maasai children: a controlled field trial

Ronán M Conroy, Michael Elmore-Meegan, Tina Joyce, Kevin G McGuigan, Joseph Barnes

“SODIS in a time of cholera”



Solar disinfection of drinking water protects against cholera in children under 6 years of age

R M Conroy, M E Meegan, T Joyce, K McGuigan, J Barnes

Arch Dis Child 2001;85:293–295

“....there were only three cases of cholera in the 155 children aged under 6 years drinking solar disinfected water compared with 20 of 144 controls”

Results of Field Trials in South Africa



Environ. Sci. Technol. 2010, 44, 8744–8749

Solar Disinfection of Drinking Water In the Prevention of Dysentery in South African Children Aged under 5 Years: The Role of Participant Motivation

MARTELLA DU PREEZ,[†]
KEVIN G. MCGUIGAN,^{*.‡} AND
RONAN M. CONROY[§]

*Natural Resources and the Environment, CSIR,
P.O. Box 395, Pretoria, South Africa, and Department of
Physiology & Medical Physics and Division of Population
Health Sciences, Royal College of Surgeons in Ireland, 123 St.
Stephens Green, Dublin 2, Ireland*

Received October 1, 2010. Accepted October 12, 2010.

Dysentery incidence rates were lower in those drinking solar disinfected water (incidence rate ratio 0.64, 95% CI 0.39-1.0, P) 0.071) but not statistically significant. Compared with the control, participants with higher motivation achieved a significant reduction in dysentery (incidence rate ratio 0.36, 95% CI 0.16-0.81, P) 0.014). However, there was no significant reduction in risk at lower levels of motivation.

Results Cambodia

High Compliance Randomized Controlled Field Trial of Solar Disinfection of Drinking Water and Its Impact on Childhood Diarrhea in Rural Cambodia

Kevin G. McGuigan,^{†*} Priyajit Samaiyar,[‡] Martella du Preez,[§] and Ronán M. Conroy^{||}

SODIS reduced incidence of dysentery, with an incidence rate ratio (IRR) of 0.50 (95% CI 0.27-0.93, $p = 0.029$).

SODIS also reduced non-dysentery diarrhea, with an IRR of 0.37 (95%CI 0.29-0.48, $p < 0.001$).



Kenya Results

Randomized Intervention Study of Solar Disinfection of Drinking Water in the Prevention of Dysentery in Kenyan Children Aged under 5 Years

Martella du Preez,[†] Ronan M. Conroy,[‡] Sophie Ligondo,[§] James Hennessy,[§] Michael Elmore-Meegan,[§] Allan Soita,[§] and Kevin G. McGuigan^{*||}

In each case $P < 0.001$

Dysentery days

IRR = 0.56 (95% CI 0.40 to 0.79));

Dysentery episodes

IRR = 0.55 (95% CI 0.42 to 0.73);

Non-dysentery days

IRR = 0.70 (95% CI 0.59 to 0.84);

Non-dysentery episodes

IRR = 0.73 (95% CI 0.63 to 0.84).



Results Kenya (cont.)

Anthropometry measurements of weight and height showed median height-for-age was significantly increased in those on SODIS, corresponding to an average of 0.8 cm over a 1-year period over the group as a whole (95% CI 0.7 to 1.6 cm, $P = 0.031$).

Hunter *et al.* suggest measurement error for height may be up to 1.4cm for children under age 2 years. Children in our study were between ages of 1 and 5 years



How safe is SODIS?

Does repeated exposure to sunlight of plastic bottles create health risk arising from photo-degradation of PET plastic and leaching of photoproducts into water?

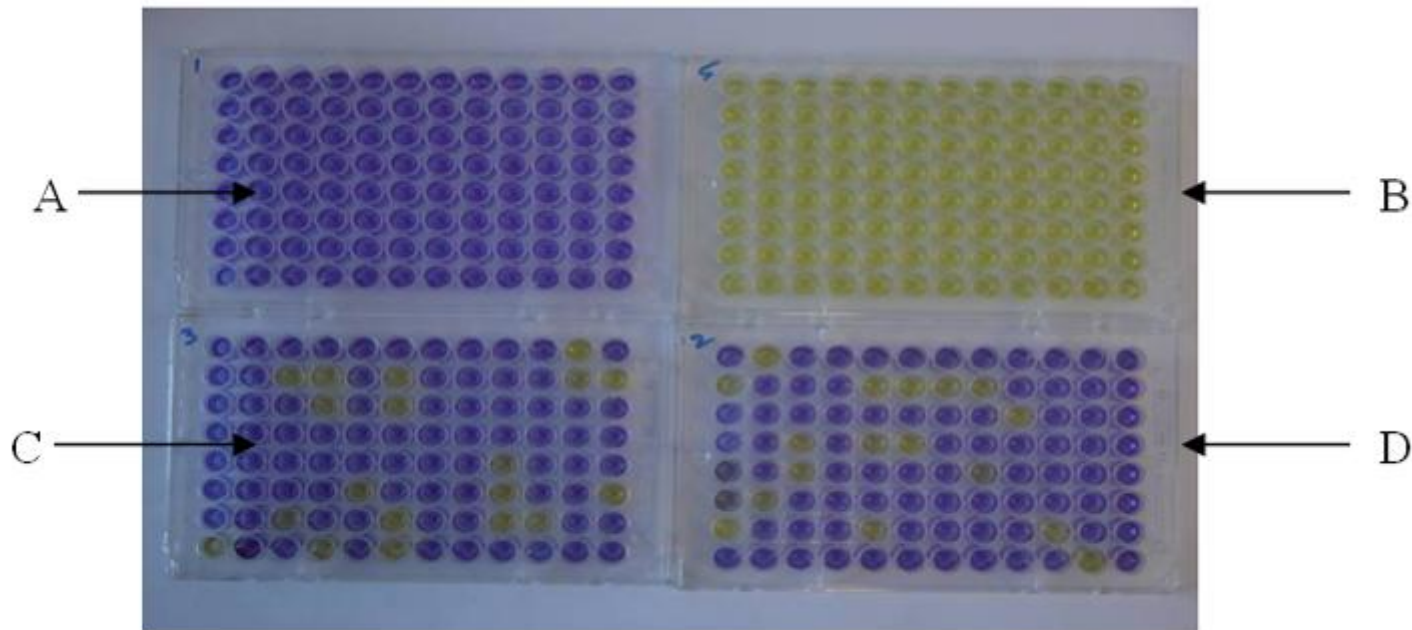


Toxicity studies

- Bottles exposed for 6 months in Southern Spain.
- Test set emptied & refilled every day
- Controls kept in dark at 22°C.
- Water tested monthly

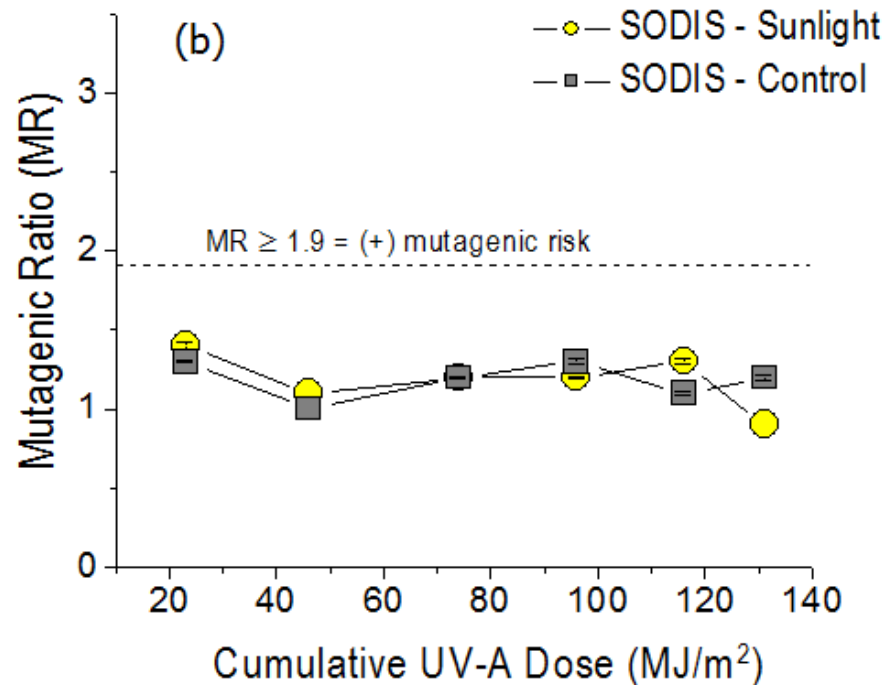
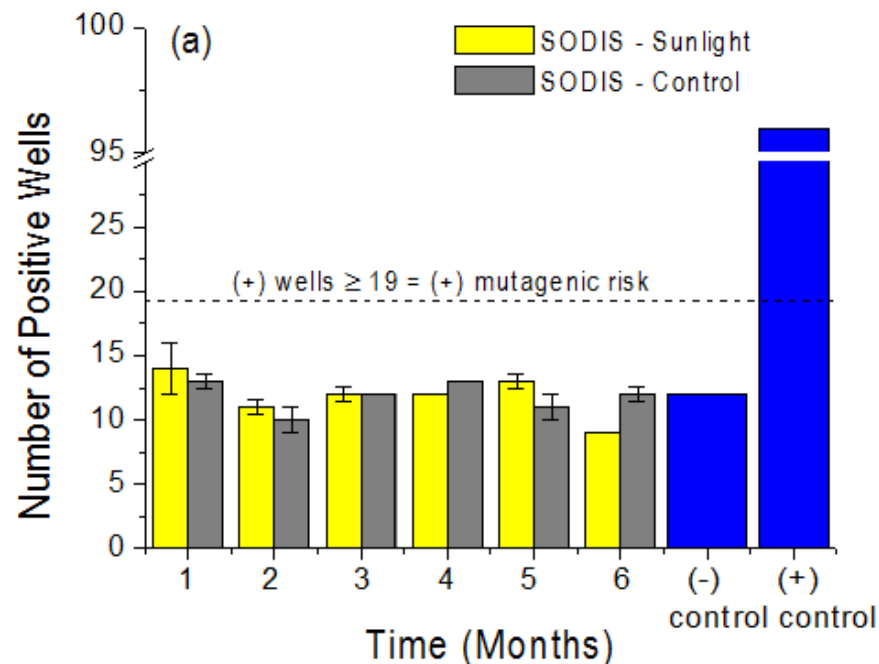


Sample added to enzyme-deficient bacteria (*S. typhimurium*). If toxic-risk exists, bacterial DNA changes causing colour change from blue to yellow.



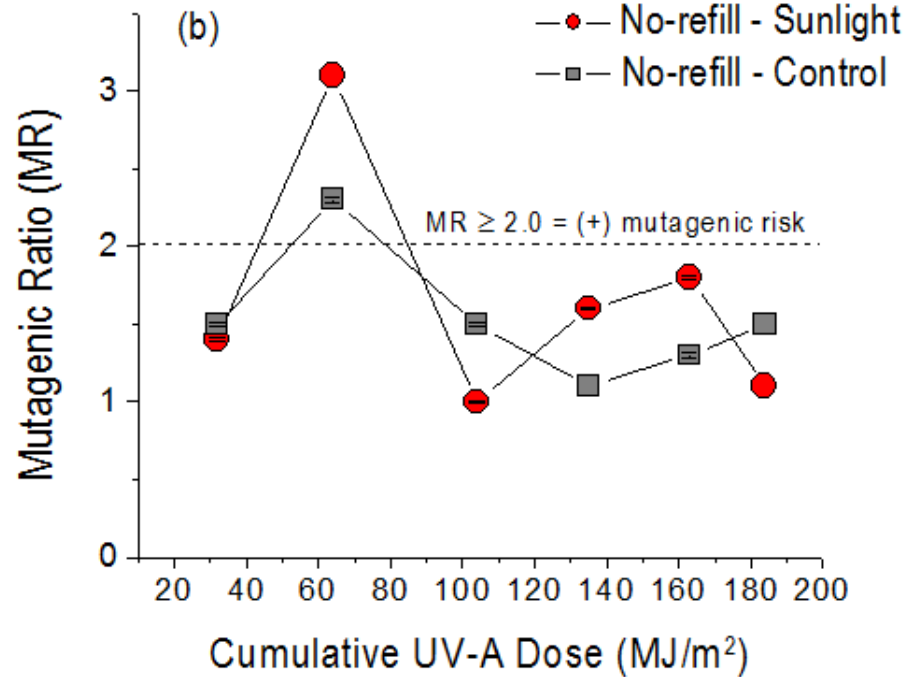
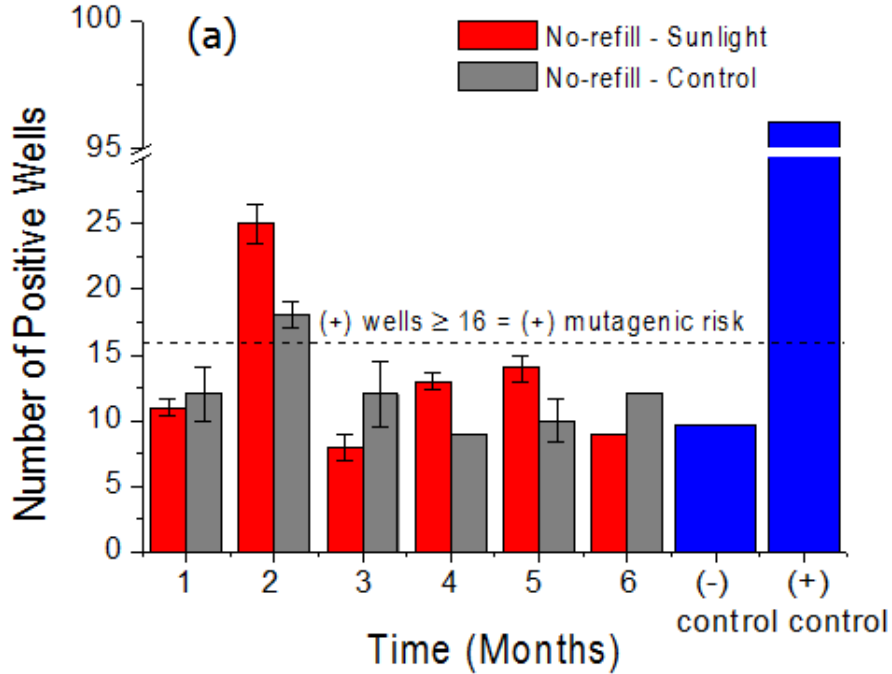
Ames-fluctuation assay in 96-well microplate: (A)-Blank sterility check, (B)-Positive control and (C & D)-Test samples

DAILY REFILL SAMPLES



SODIS daily refill samples exposed to sunlight and under dark conditions. (a) Number of positive wells (b) Mutagenic ratios. Each column/point represents the average of triplicates and error bars show the standard error limits

NO-REFILL SAMPLES



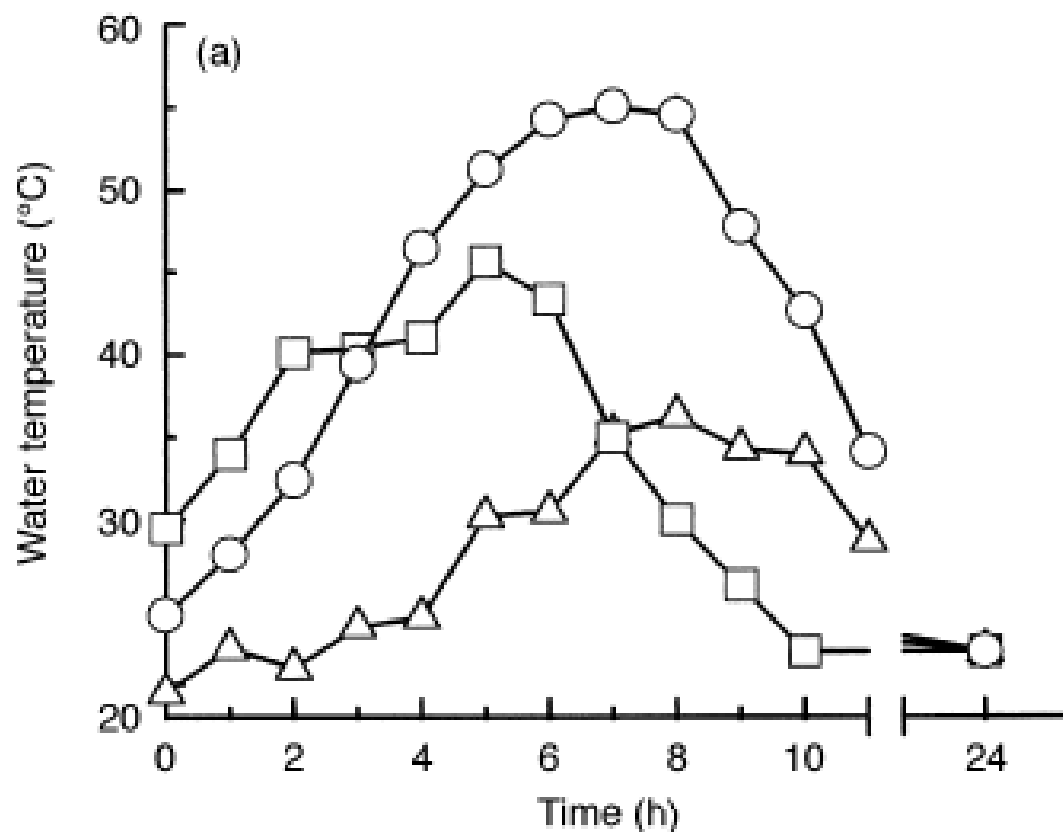
No-refill samples exposed to sunlight and under dark conditions. (a) Number of positive wells. (b) Mutagenic ratios. Each column/point represents the average of triplicates and error bars show the standard error limits

Ubomba-Jaswa et al. Journal of Water & Health. 2010;8(4):712-719

LESSONS LEARNED AFTER 20 YEARS IN THE Field

Rule No. 1: Have a realistic timescale
“No Hurry In Africa”

- In the Developing World, things always take much longer than you expect.
- It took me 6 weeks to gather data for graph opposite.



Rule No. 3

Be aware of politics in study area.

Example 1: Local Politics

Guatemala 2006



Always use local contact as driver, guide or interpreter, otherwise it will end in tears!

> 1200 deaths & > 400,000 displaced

Rule No. 3:

Be aware of politics in study area.

Example 2: National Politics

Kenya 2007-2008

- When national elections occur, developing countries can be dangerous.
- SODISWATER Project was suspended in Kenya for 3 months
- Staff attacked, injured, displaced & worse.



Rule No. 3:

Be aware of politics in study area.

Example 3: National Politics

Zimbabwe 2007-2008

- President Mugabe suspended ALL foreign projects during 2007 election campaign.
- SODISWATER Project suspended for 3 months in Zimbabwe.
- Zanu-PF vs. MDC suspicion



Rule No. 4:
Sometimes a technological solution is no solution
at all!
Example 1: Cambodia 2009



Rule No. 4: (rewording)

Elegant scientific technologies have little merit if they are too expensive for the user – Sustainability?

Example 2: Cambodia 2009



Rule No. 6:
You **MUST** have a reliable and efficient local partner that is trusted by the community.



- **Cambodia – Care International**
- **S. Africa – CSIR**
- **Kenya – ICROSS**
- **Zimbabwe – IWSD**
- **Uganda – MMM**



Some of the SODISWATER field teams in (a) S. Africa, (b) Cambodia, (c) Kenya, and (d) Zimbabwe

Rule 7:

Events are often outside your control.

Example: Zimbabwe Cholera Epidemic 2007

“Courage, Serenity, Wisdom”



- WHO/UNICEF flooded country with free chlorine tablets
- Torpedoed entire SODISWATER project in Zimbabwe



Rule 8:

Get yourself a really good project finance controller

Financial expertise provided by RCSI Finance Office was invaluable in project especially when dealing with EU and/or “uncooperative” partners.



What have we learned after 20 years of SODIS research in the lab and in the field?



- If used, SODIS reduces dysentery and diarrhoea rates in children by between 20% and 50%. If not used, SODIS CAN'T work.
- SODIS creates a benefit in child height (median increased by 0.8 cm)
- Technologies must work well in the lab but that may not be enough (economic sustainability?)
- Technology will only be used if user can afford it & sees a need

What have we learned after 20 years of SODIS research in the lab and in the field?

- The technology must work.
- Get a reliable local partner.
- Get a respected local “advocate/ambassador” to promote your technology.
- Economic benefits are as powerful as Health benefits when promoting to users.
- If the economics are not right the technology will not be used.



Where Next?

What Next?

Water is Life Project in Uganda:

- SODIS introduction in rural primary schools. Studying if this is as effective as when promoted at community level.
- Solar disinfection of harvested rainwater



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Department of Foreign Affairs
An Roinn Gnóthaí Eachtracha



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