



Solar Water Pasteurization

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Project Sponsors

- Pocono Northeast Resource Conservation & Development Council
<http://www.pnercd.org>
- C-SAW Program - Consortium for Scientific Assistance to Watersheds Program <http://pa.water.usgs.gov/csaw/>
- Carbon County Groundwater Guardians
<http://www.carbonwaters.org>
- PA Association of Environmental Professionals
<http://www.paep.org>

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Solar Water Pasteurization

- Safe water supply – worldwide
 - Still a significant problem
 - Also → emergency situations
- Can the sun be used to provide safe drinking water for:
 - Drinking?
 - Meal preparation?
 - Teeth Cleaning?
 - Preparation of infant formula?



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Solar Cat

A cat sunning himself in the doorway of a barn knows all about solar energy.

- Why can't people learn?
- E.B. White



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Solutions to the Energy Crisis by Hilary B. Price "Rhymes with Orange"



Sun Ovens at the Institute for Solar Living, Hopland, CA



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Sterilization vs. Pasteurization

- Sterilization is the killing of all microorganisms
- Pasteurization is the application of less-than boiling temperatures to foods to prevent the growth of various heat-labile pathogens
- Does water have to be boiled to make it safe?
 - Energy requirements
 - Air pollution → burning of fossil fuels
 - Costs
 - Time

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Can we pasteurize water to make it safe to use?

- The “father” of solar water pasteurization is Dr. Robert Metcalf, a microbiologist at Cal State Sacramento



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Heat Sensitivity of Some Pathogenic Microbes

- Chart (from Dr. Metcalf) → the temperatures at which the most common waterborne pathogens are rapidly killed (90% becoming inactivated in one minute at the given temperature → used to express the heat sensitivity of various microbes):

Microbe	Killed Rapidly At
Worms, Protozoa cysts (<i>Giardia</i> , <i>Cryptosporidium</i> , <i>Entamoeba</i>)	55°C (131°F)
Bacteria (<i>V. cholerae</i> , <i>Escherichia coli</i> , <i>Shigella</i> , <i>Salmonella typhi</i>), Rotavirus	60°C (140°F)
Hepatitis A virus	65°C (149°F)

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How can you determine if the water is safe to drink?

- Test the water for bacterial indicators of fecal pollution



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What is an indicator organism?

Hach Company, 2000

The Use of Indicator Organisms to Assess Public Water Safety
Technical Information Series—Booklet No. 13

Certain criteria should exist before an indicator organism can be considered reliable in predicting a health risk:

1. The organism must be exclusively of fecal origin and consistently present in fresh fecal waste.
2. It must occur in greater numbers than the associated pathogen.
3. It must be more resistant to environmental stresses and persist for a greater length of time than the pathogen.
4. It must not proliferate to any great extent in the environment.
5. Simple, reliable, and inexpensive methods should exist for the detection, enumeration, and identification of the indicator organism.

Organisms that fit these criteria include the coliform bacteria, fecal streptococci (enterococci) and the sulfite-reducing clostridia (i.e., *Clostridium perfringens*).

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Enterobacteriaceae

Hach Company, 2000

The Use of Indicator Organisms to Assess Public Water Safety
Technical Information Series—Booklet No. 13

Gastrointestinal pathogens known to have caused outbreaks of enteric disease are largely from the systematically defined family, Enterobacteriaceae, and include *Salmonella*, *Shigella*, *Yersinia enterocolitica*, *Klebsiella pneumoniae*, *Enterobacter* and enterotoxigenic *Escherichia coli* (*E. coli*), *Vibrio cholerae* and *Campylobacter jejuni* are two other enteric pathogens often found in contaminated water.² These organisms are spread by water contaminated with fecal material from humans and other warm-blooded animals.

Figure 1 Relationship of Bacteria in Enterobacteriaceae Family



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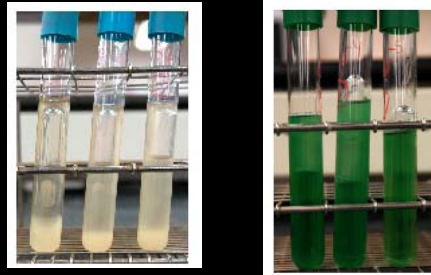
Selected Methods for Counting Indicator and Opportunistic Organisms (Hach)

- **Most Probable Number Tests (MPN)**
 - Total Coliforms
 - Fecal Coliforms
 - Fecal Streptococci
 - *Pseudomonas aeruginosa*

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MPN

(http://www.bact.wisc.edu/Microtextbook/images/book_3/chapter_15/15-3.jpg)



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Selected Methods for Counting Indicator and Opportunistic Organisms (Hach) - continued

- **Membrane Filtration**
 - Total Coliform Bacteria
 - Fecal Coliforms
 - *Escherichia coli*
 - Fecal Streptococci
 - Enterococci
 - *Pseudomonas aerogenes*

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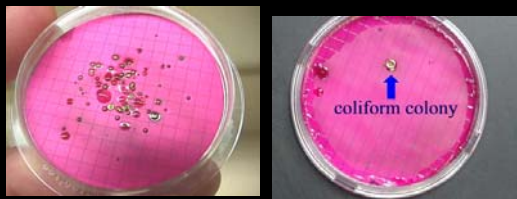
Membrane Filtration (Mr. Brian Oram, Wilkes University, EQC)

<http://www.wilkes.edu>



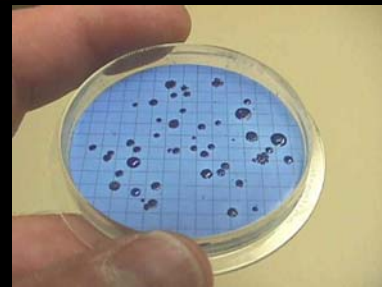
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Membrane Filtration – Total Coliforms (Mr. Brian Oram, Wilkes University EQC)



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Membrane Filtration -Fecal Coliform (Mr. Brian Oram, Wilkes University EQC)



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Selected Methods for Counting Indicator and Opportunistic Organisms (Hach) - continued

- **Presence / Absence Test**
 - BART™ - Biological Activity Reaction Test
 - Presence/ Absence Media with Mug and without Mug
- **Plate Count Method**

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Presence Absence Test (Hach)

- This is a presumptive detection test for coliforms in water and is based on the presence or absence of lactose fermentation.
- The media is composed of lactose (carbon source), beef extract and peptones (nutrients/amino acid source), potassium phosphate (buffer), sodium chloride (salt), and sodium lauryl sulfate (selective agent- inhibits many organism other than coliform group).
- The indicator is a bromeresol purple dye.
 - If fermentation occurs and acids generated, the indicator turns from purple to yellow. This reaction confirms the presence of the fermentation of the lactose (acid reaction).

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P/A – Sample Processing

- 1) 50 ml of Triple Strength P-A Broth;
- 2) 100 ml sample;
- 3) Replace cap and invert the bottle several time to mix;
- 4) Incubate at 35° C ± 0.5 °C for 24 and 48 hours;
- 5) Check sample after 24 hours and 48-hours – note color and presence of gas production

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Presence /Absence Broth

(Mr. Brian Oram, Wilkes University EQC)



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Presence Absence with MUG

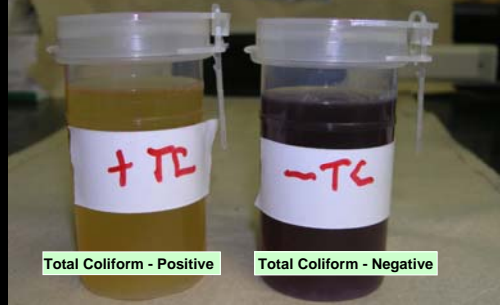
- This is the same P-A Media, but MUG has been added. MUG is methylumbellifery-β-D glucuronide.
- Because *E. coli* produces a β-D-glucuronidase enzyme, this enzyme will hydrolyze the MUG to produce a by-product that will fluoresce.
- The fluorescence can be seen using long-wave UV light, such as 366 nanometers.



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Total Presence / Absence Testing for the Coliform Group

(Mr. Brian Oram – Wilkes University EQC)



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Presence/ Absence Media with MUG
(Mr. Brian Oram, Wilkes University EQC)

Blank - no bacterial spike (sterile water)
ATCC 10145 - *Pseudomonas aeruginosa*
ATCC 11775 - *E. coli*
ATCC 13048 *E. aerogenes*

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Presence / Absence Testing with MUG
E. Coli Confirmation- Positive Samples **Fluoresce**
(Mr. Brian Oram, Wilkes University EQC)

Blank - no bacterial spike (sterile water)
ATCC 10145- *Pseudomonas aeruginosa*
ATCC 11775 - *E. coli* - (note **fluorescence**)
ATCC- 13048 *E. aerogenes*

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Confirmation Testing with LTB and BGLB
Total Coliform Confirmation Testing –
Air Incubator at 35°C (48 hours)
(Mr. Brian Oram, Wilkes University, EQC)

Positive- Note the growth and the gas production
Negative – Note no growth and no gas production

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ATCC- 11775 - *E. coli* (growth and gas)
ATCC- 10145- *Pseudomonas aeruginosa*
(no growth and no gas)

(Mr. Brian Oram, Wilkes University EQC)

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E. Coli Confirmation – Using EC Media
(Incubated - Water Bath 44.5 °C)
(Mr. Brian Oram, Wilkes University EQC)

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Other Bacterial Problems – “Nuisance Bacteria”
Biological Activity Reaction Test (BART™)
(Mr. Brian Oram, Wilkes University EQC)

Iron Related Bacteria
Slime Bacteria
Sulfur Related Bacteria

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Plate Count

http://www.baet.wisc.edu/Microtextbook/index.php?module=Book&func=displaychapter&chap_id=55&theme=Printer



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Solar Water Pasteurizer Made from Everyday Recyclables

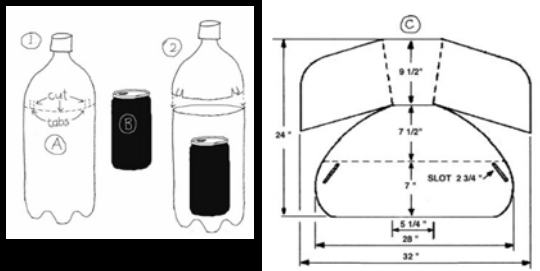
<http://solarcooking.org/soda-bottle-pasteurizer.htm>

- **Materials:**
 - 2 liter clear plastic soda bottle
 - 12 oz aluminum soda can
 - Corrugated cardboard (1/4" x 24" x 32")
 - Aluminum foil
- **Goal:**
 - To pasteurize → Water must be heated to 158 °F (70 °C) for at least 15 minutes

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Solar Water Pasteurizer Made from Everyday Recyclables

<http://solarcooking.org/soda-bottle-pasteurizer.htm>

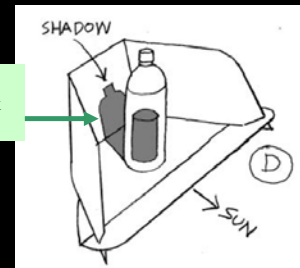


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Solar Water Pasteurizer Made from Everyday Recyclables

<http://solarcooking.org/soda-bottle-pasteurizer.htm>

Keep bottle shadow centered on the back of the solar panel



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"Is it soup yet?"

Robert Metcalf
Professor, Biological Sciences
California State University, Sacramento

- **WAPI – Water Pasteurization Indicator**
 - Prototype was developed by Dr. Fred Barrett (USDA, retired) in 1988 and improved by Dale Andreatta, an engineering graduate student UC Berkeley
- → Essentially a tube which contains a soybean fat which melts at 69° C.
- When the fat melts, it flows down from the top to the bottom of the tube, which indicates that the water has been pasteurized.
- WAPI are reusable (just turn them upside down).



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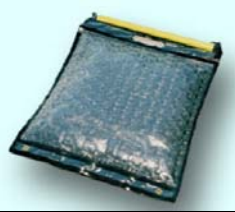
WAPI

Robert Metcalf
Professor, Biological Sciences
California State University, Sacramento

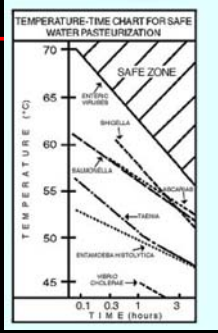


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AquaPak™
AquaPak, A Solar Water Pasteurizer
Now Ready for World Distribution



<http://www.solarsolutions.info/aquapak/aquapak.html>



TEMPERATURE-TIME CHART FOR SAFE WATER PASTEURIZATION

70
65
60
55
50
45

TEMPERATURE (°C)

0.1 0.5 1 3
T. I. M. E. (hours)

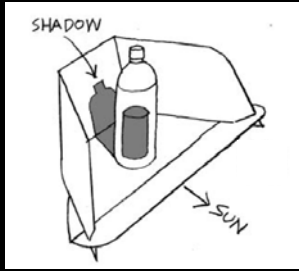
SAFE ZONE

Salmonella
E. coli
Vibrio cholerae
Shigella
Yersinia
Enterobacteriaceae
Listeria monocytogenes

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Let's go pasteurize some water!

(<http://solareoking.org/soda-bottle-pasteurizer.htm>)



SHADOW

SUN

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