Solar Water Pasteurization

Prepared by:

Dr. Marleen Troy, PE and
Mr. Brian Oram, PG
Keystone Clean Water Team

http://www.water-research.net

http://www.pacleanwater.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?**

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**

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

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

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**

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**
- **(Solar Cookers International Volunteer)**

PPLIED AND ENVIRONMENTAL MICROBIOLOGY, Feb. 1984, p. 223–228
99-2240/84/020223-06$02.00/0
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Vol. 47, N

Pasteurization of Naturally Contaminated Water with Solar Energy

DAVID A. CIOCHETTI † AND ROBERT H. METCALF*
Department of Biological Sciences, California State University, Sacramento, Sacramento, California 95819

Received 25 July 1983/Accepted 7 November 1983

A solar box cooker (SBC) was constructed with a cooking area deep enough to hold several 3.7-liter jugs of water, and this was used to investigate the potential of using solar energy to pasteurize naturally contaminated water. When river water was heated either in the SBC or on a hot plate, coliform bacteria were inactivated at temperatures of 60°C or greater. Heating water in an SBC to at least 65°C ensures that the water will be above the milk pasteurization temperature of 62.8°C for at least an hour, which appears sufficient to pasteurize contaminated water. On clear or partly cloudy days, with the SBC facing magnetic south in Sacramento, bottom water temperatures of at least 65°C could be obtained in 11.1 liters of water during the 6 weeks on either side of the summer solstice, in 7.4 liters of water from mid-March through mid-September, and in 3.7 liters of water an additional 2 to 3 weeks at the beginning and end of the solar season. Periodic repositioning of the SBC towards the sun, adjusting the back reflective lid, and preheating water in a simple reflective device increased final water temperatures. Simultaneous cooking and heating water to pasteurizing temperatures was possible. Additional uses of the SBC to pasteurize soil and to decontaminate hospital materials before disposal in remote areas are suggested.

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Feb. 1999, p. 859–861
0099-2240/99/$04.00+0
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Vol. 65, No. 2

Enhancement of Solar Water Pasteurization with Reflectors

NEGAR SAFAPOUR† AND ROBERT H. METCALF*
Department of Biological Sciences, California State University Sacramento, Sacramento, California 95819-6077

Received 13 July 1998/Accepted 3 November 1998

A simple and reliable method that could be used in developing countries to pasteurize milk and water with solar energy is described. A cardboard reflector directs sunshine onto a black jar, heating water to pasteurizing temperatures in several hours. A reusable water pasteurization indicator verifies that pasteurization temperatures have been reached.

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 (***Giardia, Cryptosporidium, Entamoeba***)	55°C (131°F)
Bacteria (***V. cholerae, Escherichia coli, Shigella, Salmonella typhi***), **Rotavirus**	60°C (140°F)
Hepatitis A virus	65°C (149°F)

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

- **Test the water for bacterial indicators of fecal pollution**

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*).

Enterobacteriacea

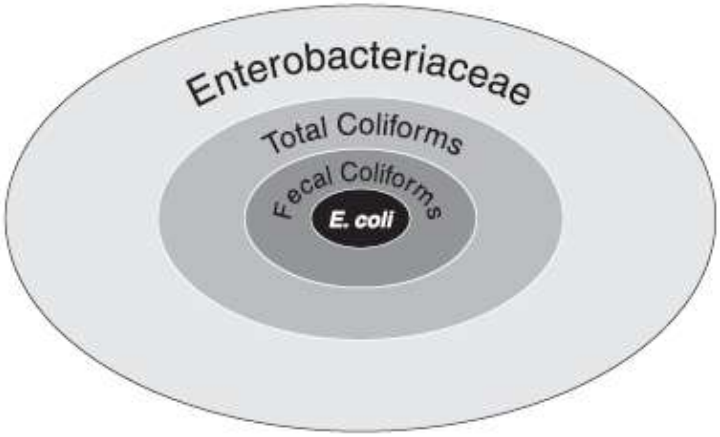
Hach Company, 2000

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

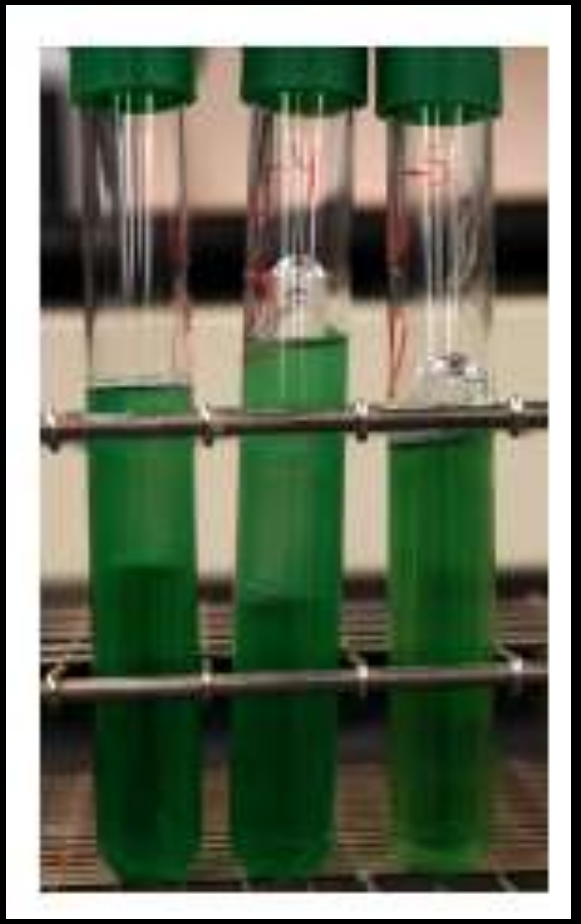


Selected Methods for Counting Indicator and Opportunistic Organisms (Hach)

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

MPN

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



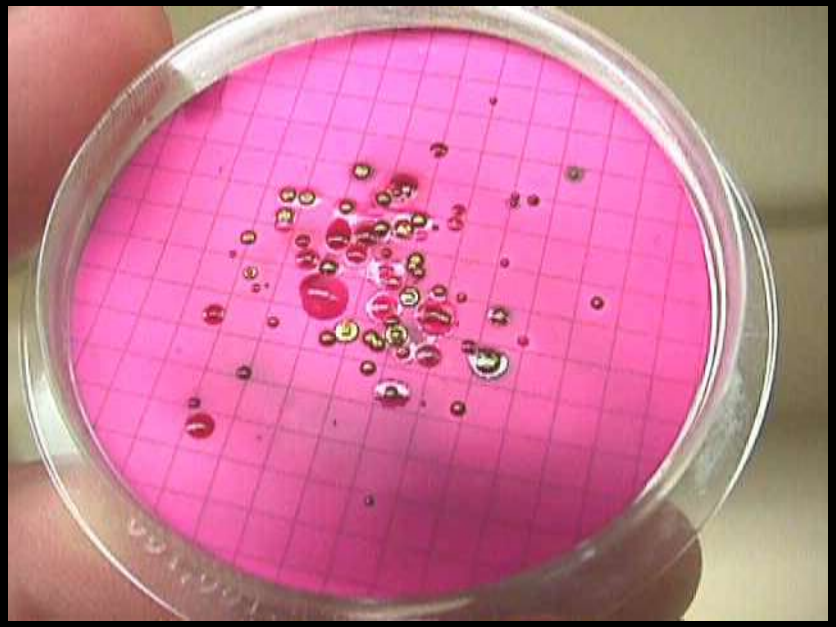
Selected Methods for Counting Indicator and Opportunistic Organisms (Hach) - continued

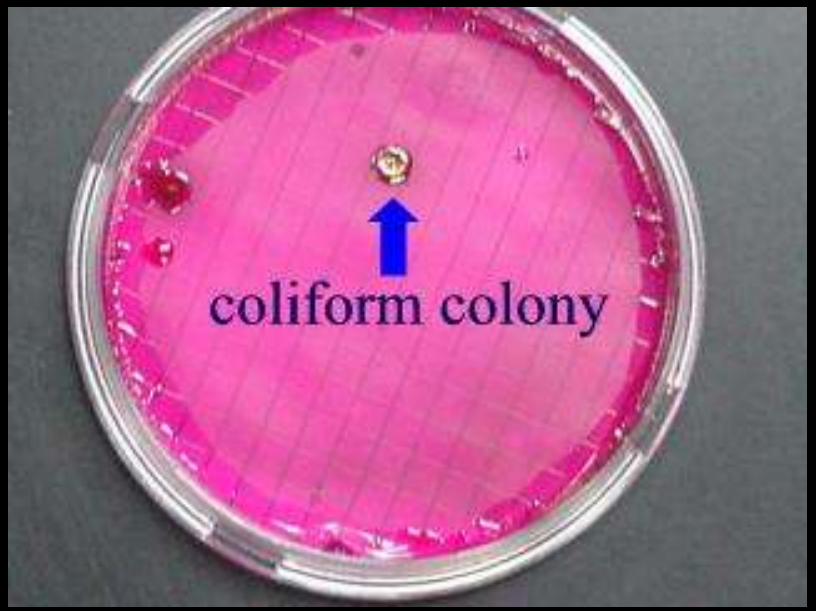
- **Membrane Filtration**
  - **Total Coliform Bacteria**
  - **Fecal Coliforms**
  - ***Escherichia coli***
  - **Fecal Streptococci**
  - **Enterococci**
  - ***Pseudomonas aerogenes***

Membrane Filtration
(Mr. Brian Oram)

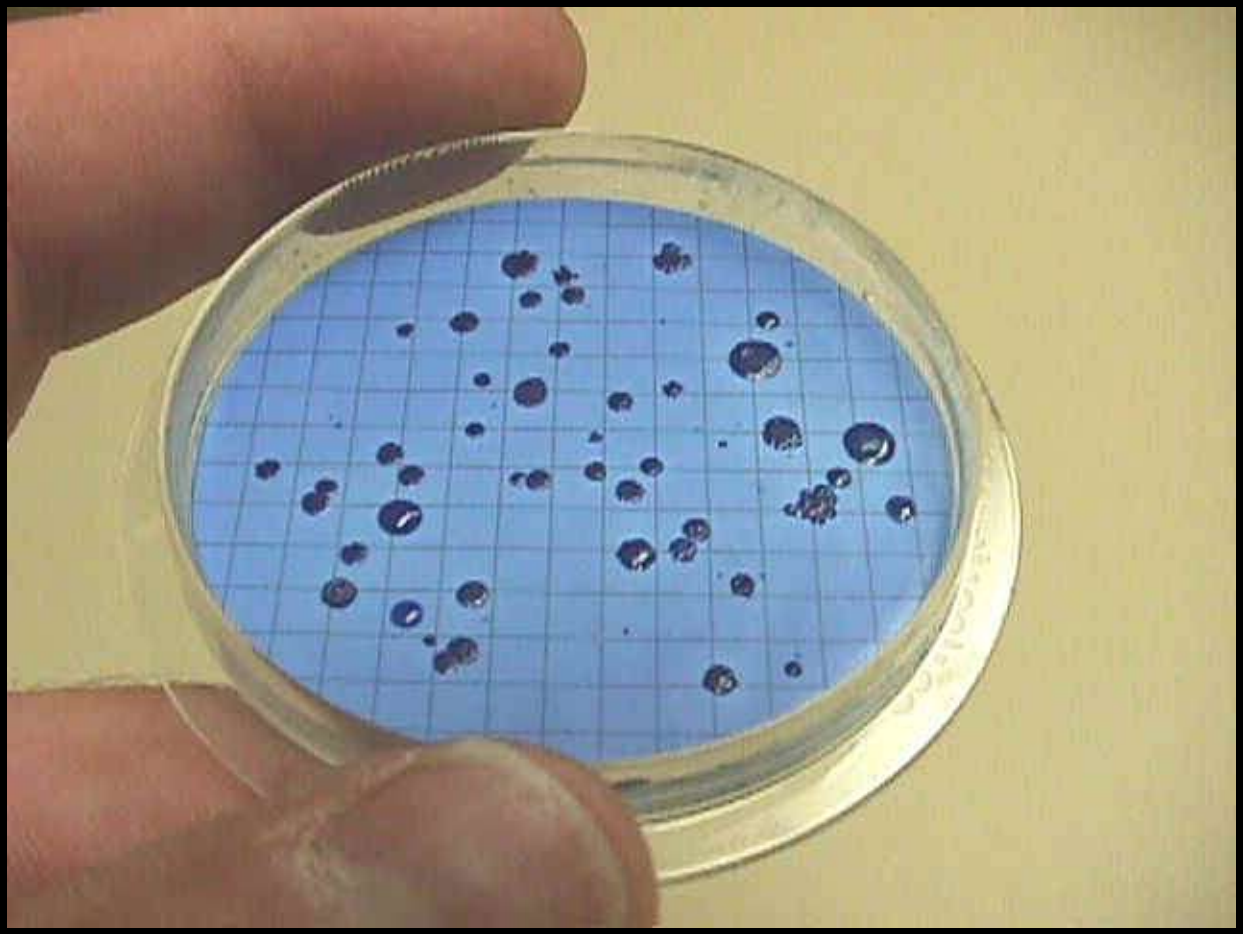
http://www.water-research.net

Membrane Filtration – Total Coliforms (Mr. Brian Oram)





Membrane Filtration -Fecal Coliform
(Mr. Brian Oram)



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**

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 bromcresol 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).**

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 35º C 0.5 ºC for 24 and 48 hours;

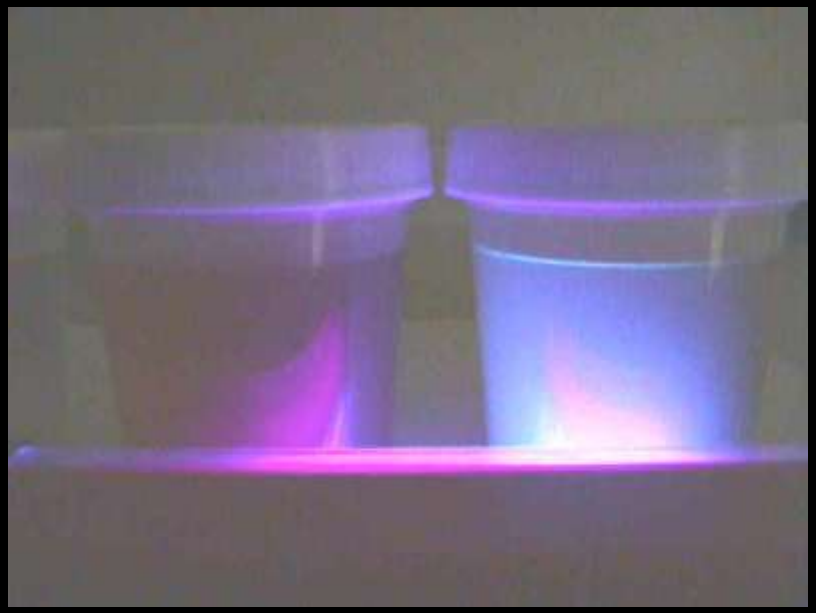
5) Check sample after 24 hours and 48-hours – note color and presence of gas production

Presence /Absence Broth

(Mr. Brian Oram)

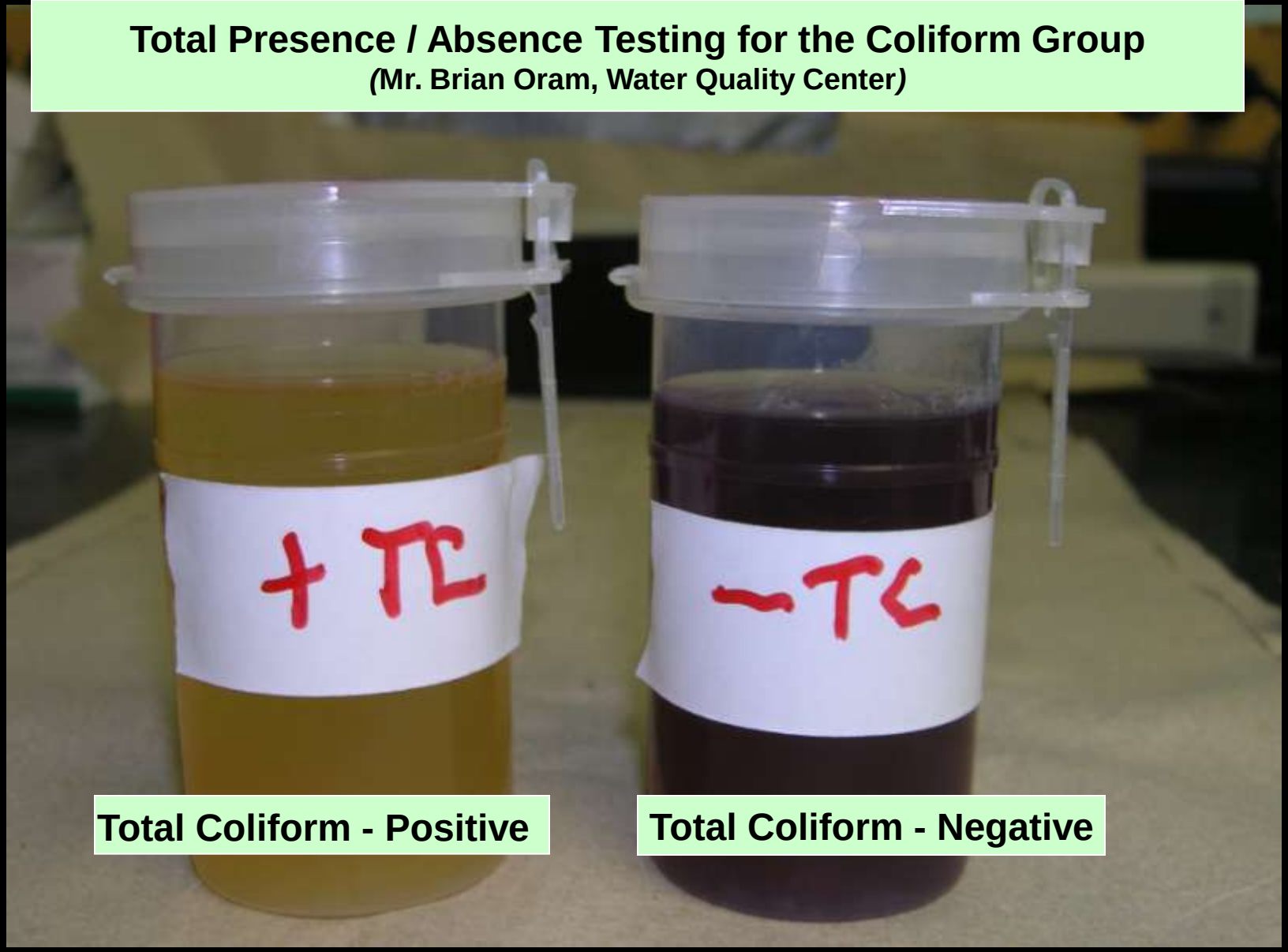
Presence Absence with MUG

- **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.**



Total Presence / Absence Testing for the Coliform Group

*(*Mr. Brian Oram, Water Quality Center*)*

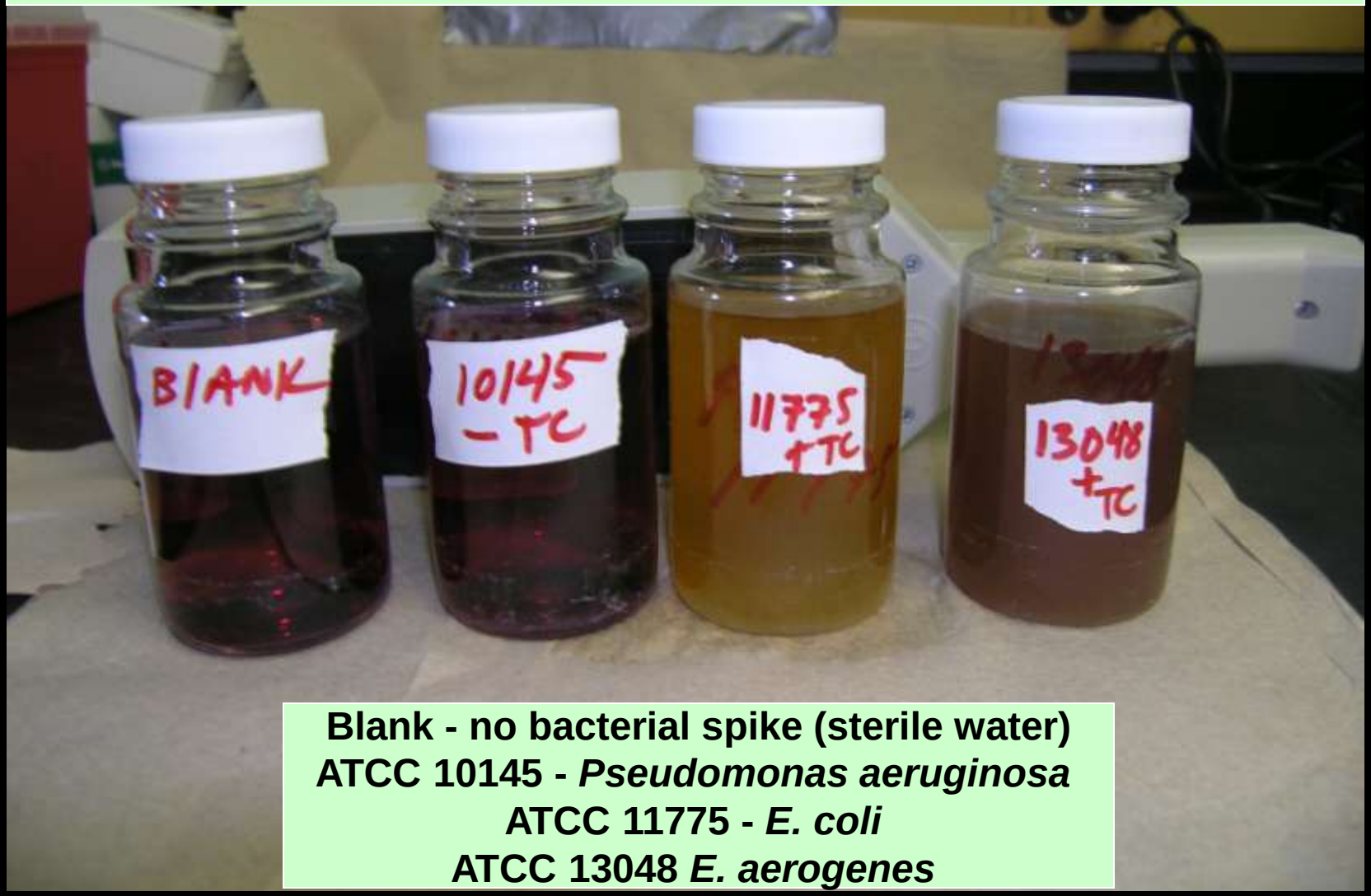


Total Coliform - Positive

Total Coliform - Negative

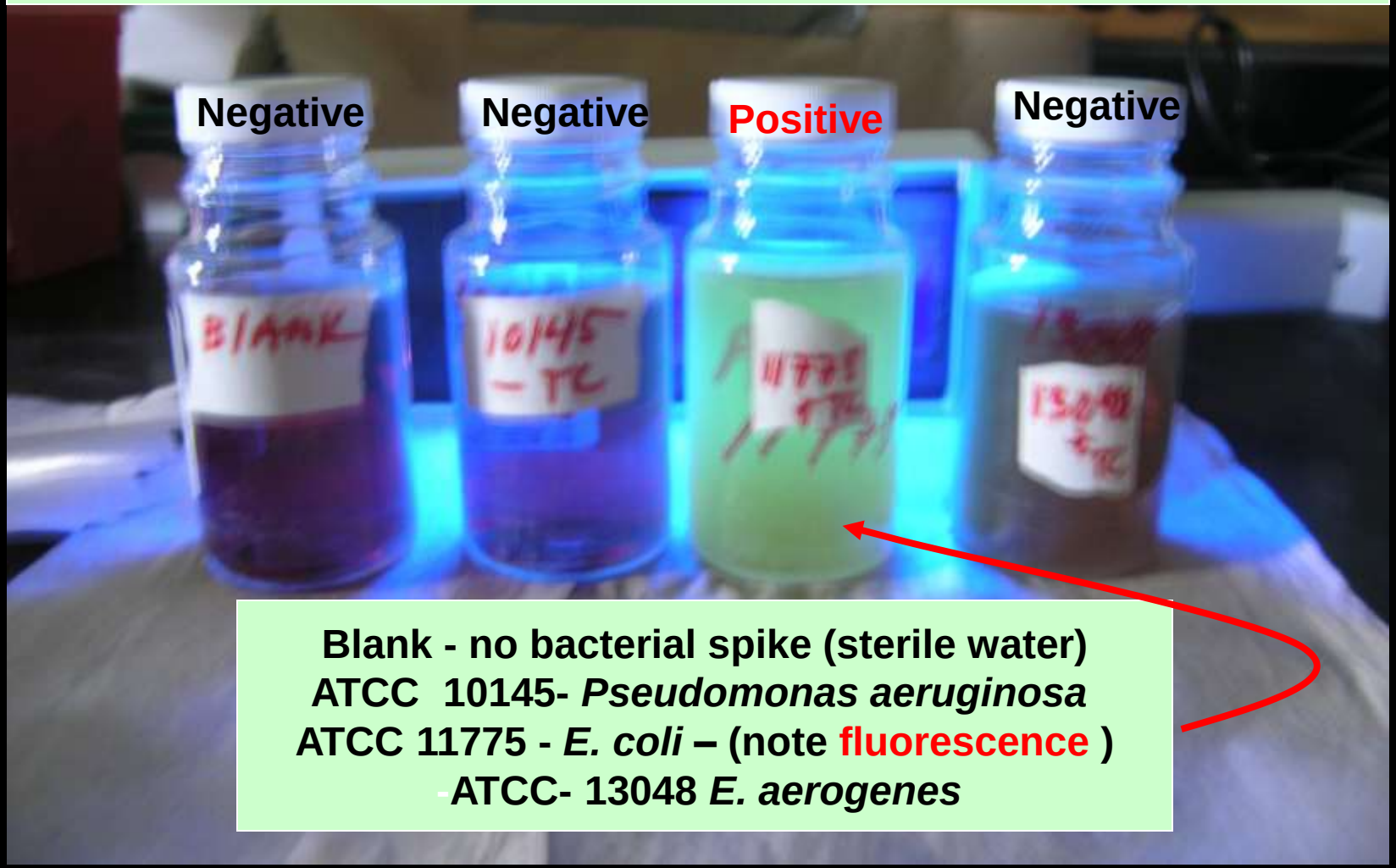
Presence/ Absence Media with MUG

*(*Mr. Brian Oram, Water Quality Center*)*



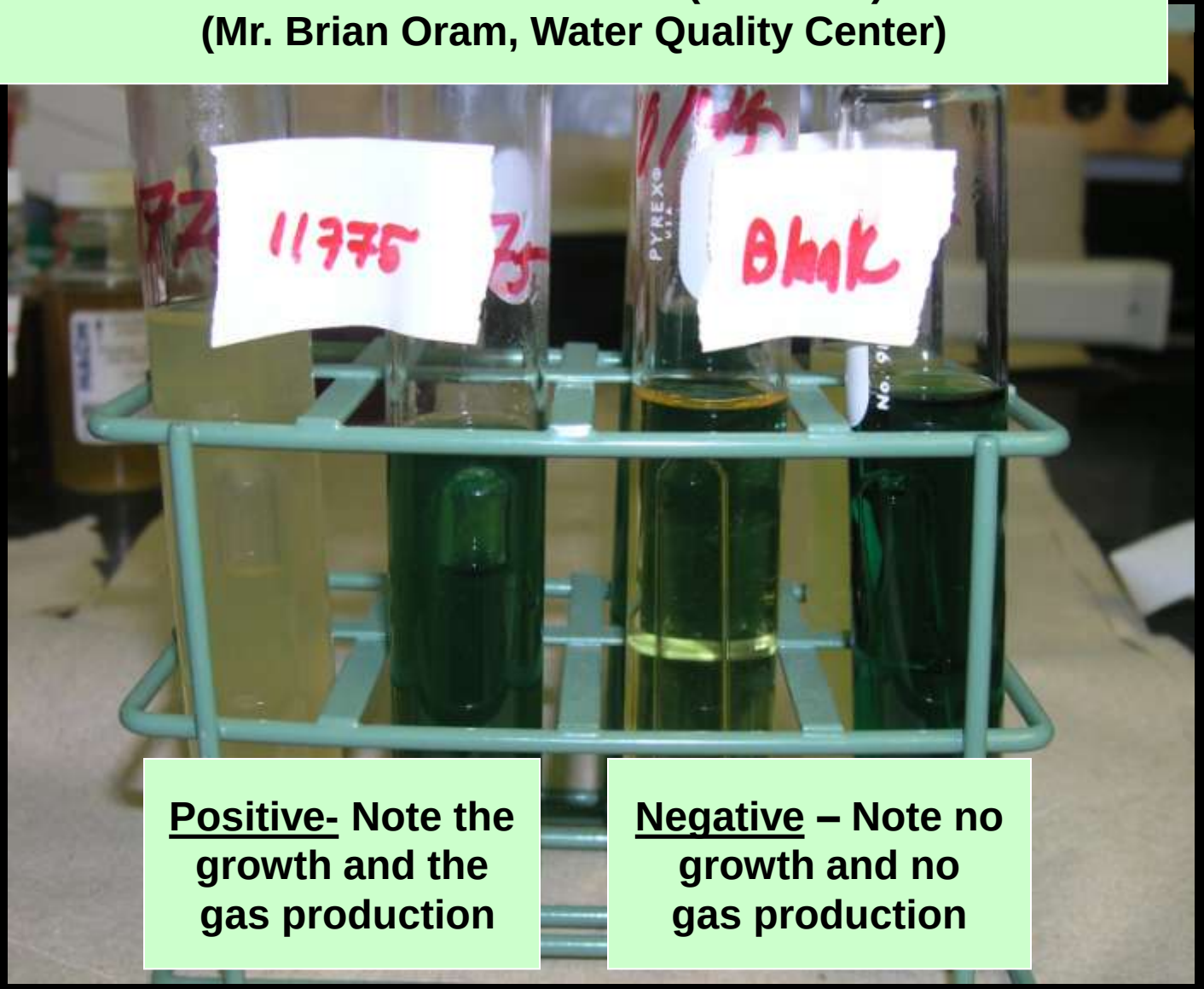
Blank - no bacterial spike (sterile water)
ATCC 10145 - *Pseudomonas aeruginosa*
ATCC 11775 - *E. coli*
ATCC 13048 *E. aerogenes*

Presence / Absence Testing with MUG
E. Coli Confirmation- Positive Samples Fluoresce
(Mr. Brian Oram, Water Quality Center)



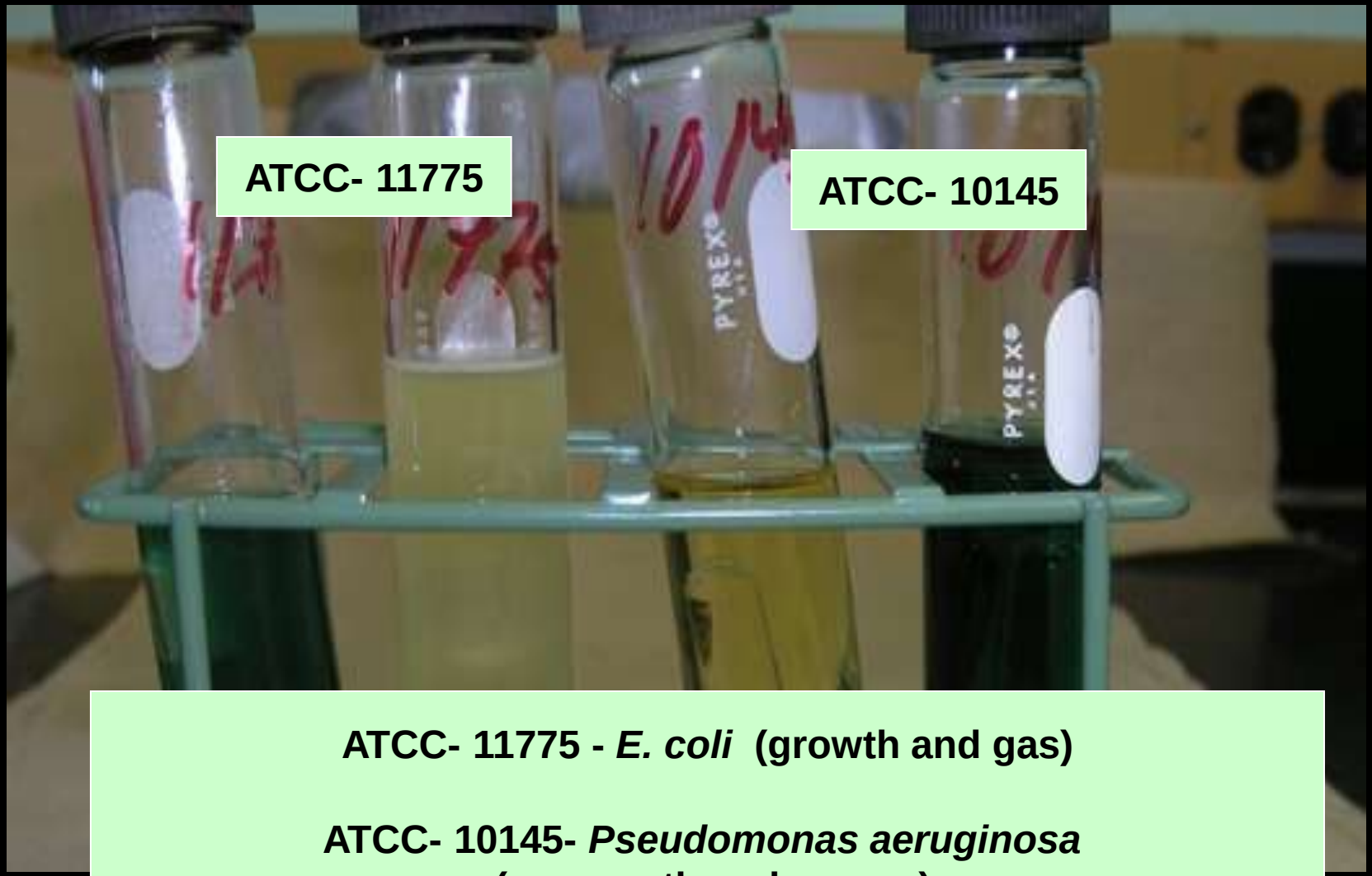
Blank - no bacterial spike (sterile water)
ATCC 10145- *Pseudomonas aeruginosa*
ATCC 11775 - *E. coli* – (note fluorescence)
ATCC- 13048 *E. aerogenes*

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



<u>Positive-</u> Note the growth and the gas production

<u>Negative</u> – Note no growth and no gas production



ATCC- 11775 - *E. coli* (growth and gas)

ATCC- 10145- *Pseudomonas aeruginosa*
(no growth and no gas)

(Mr. Brian Oram, Water Quality Center))

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

Other Bacterial Problems – "Nuisance Bacteria"
Biological Activity Reaction Test (BART™)
(Mr. Brian Oram, Water Quality Center)

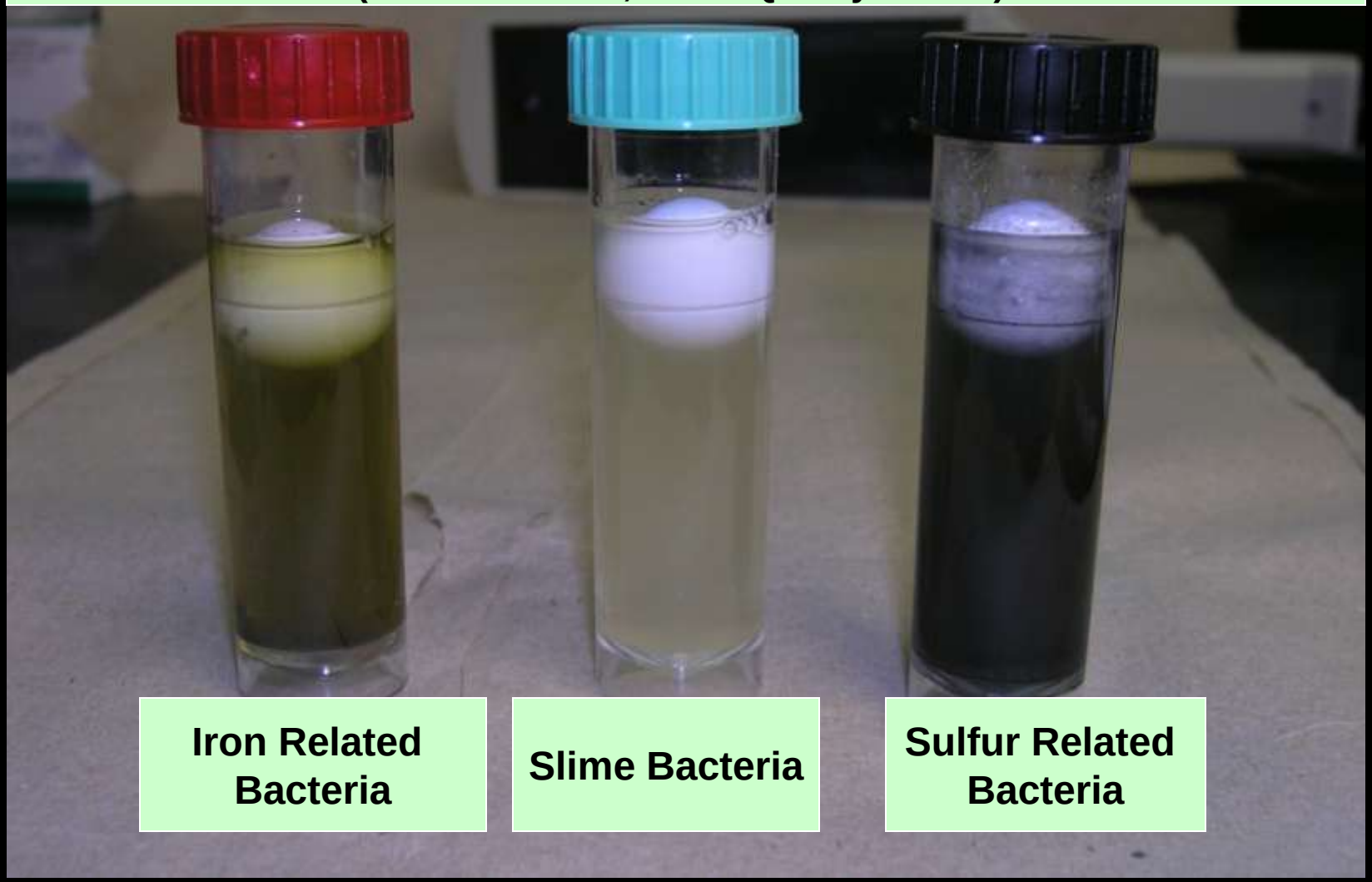
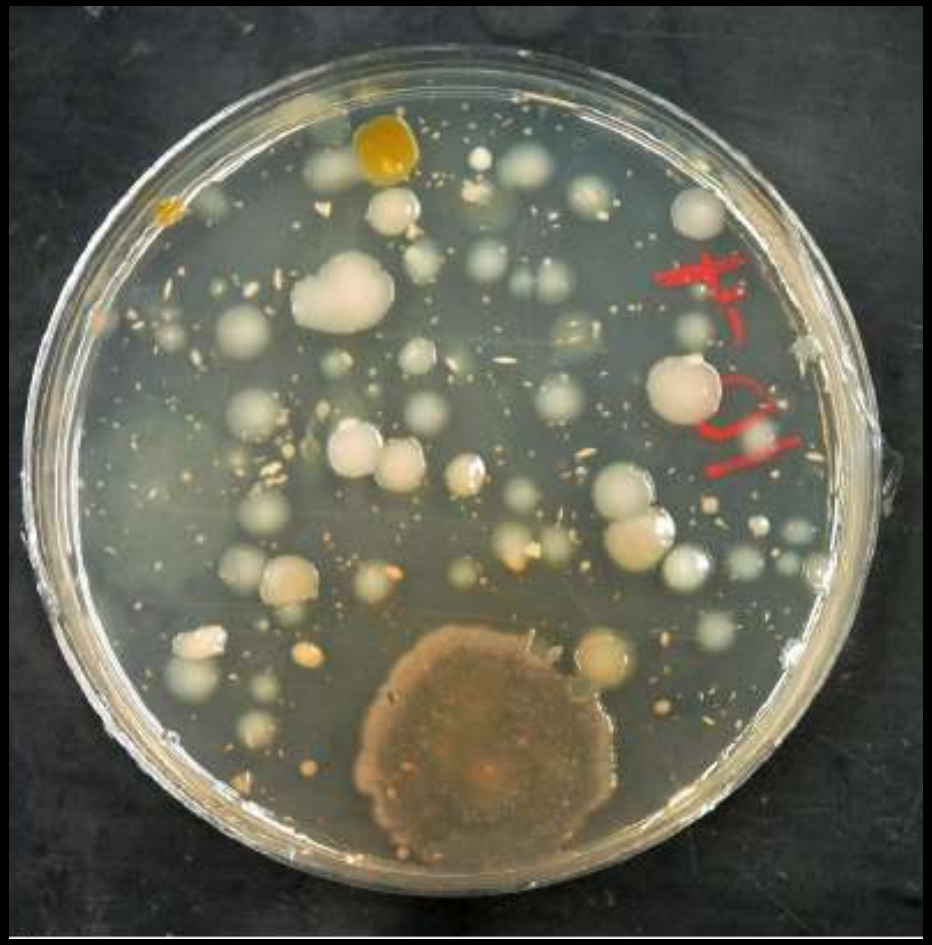


Plate Count

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

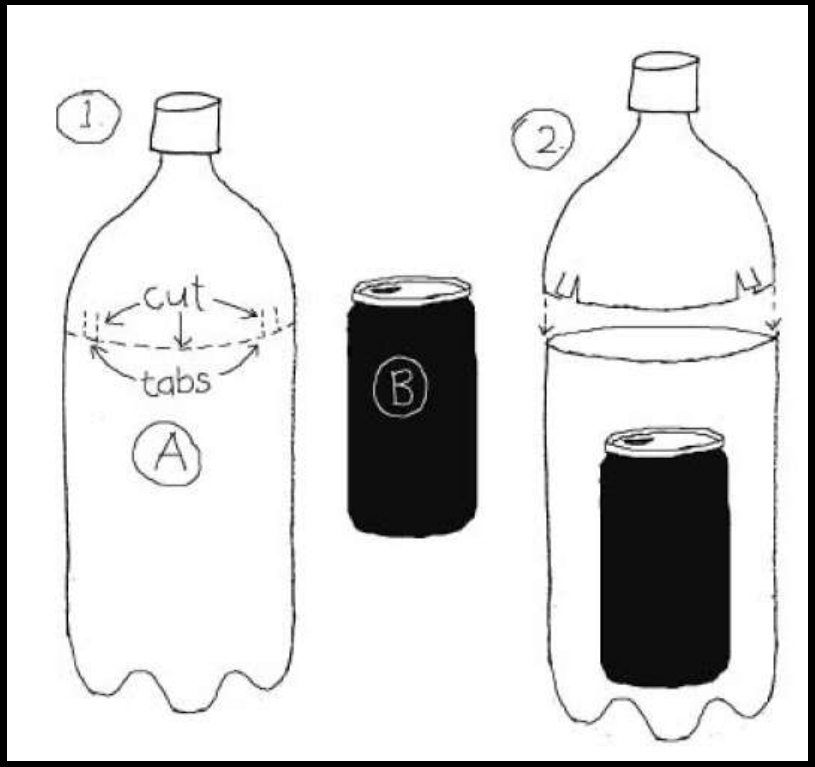


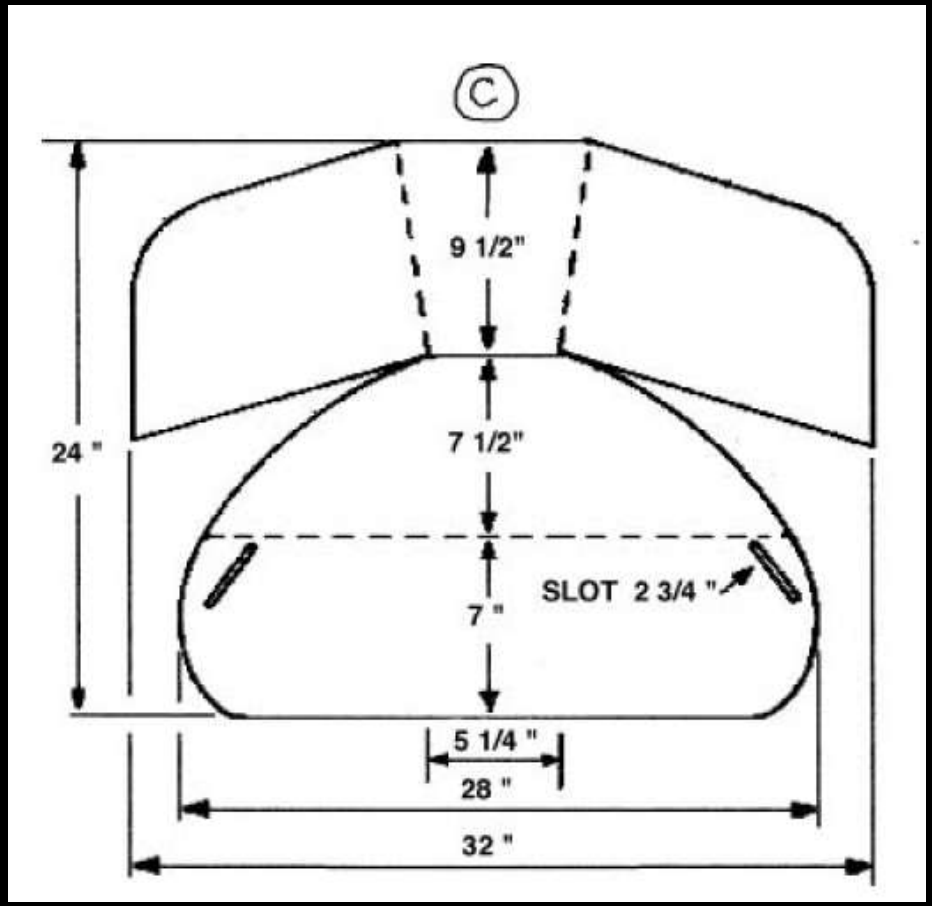
Solar Water Pasteurizer Made from Everyday Recyclables
(http://solarcooking.org/soda-bottle-pasteurizer.htm)

- **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 ºF (70 ºC) for at least 15 minutes**

Solar Water Pasteurizer Made from Everyday Recyclables

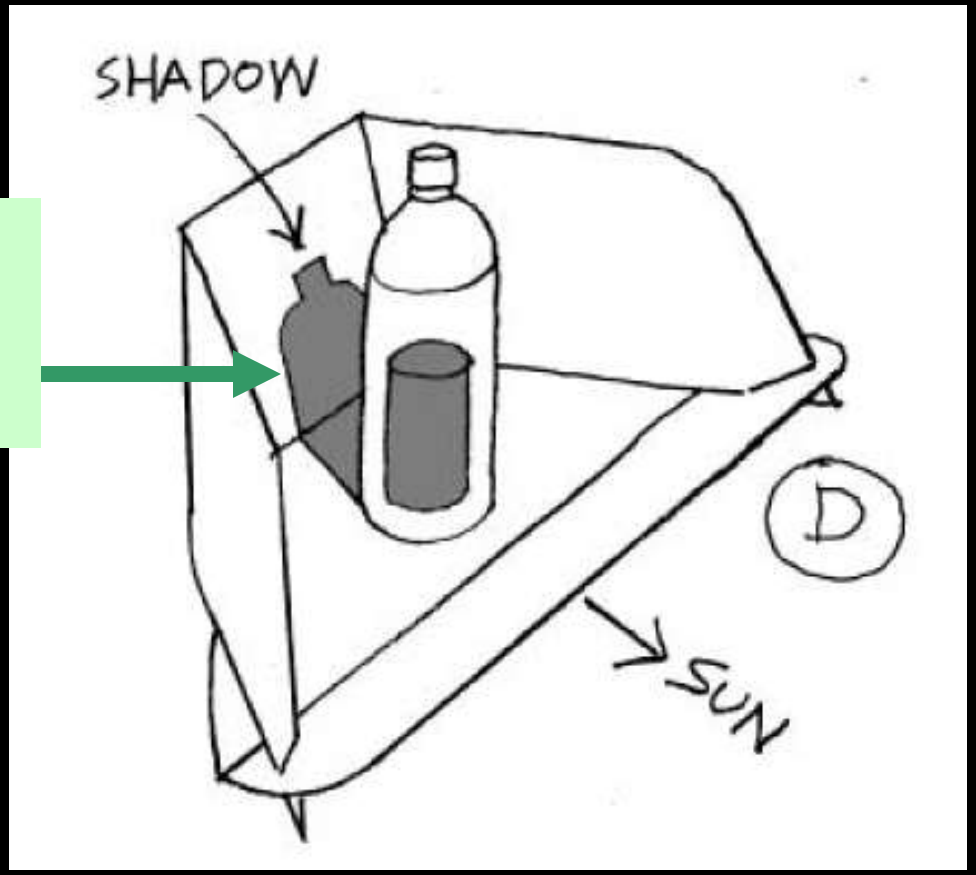
(http://solarcooking.org/soda-bottle-pasteurizer.htm)





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



"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**

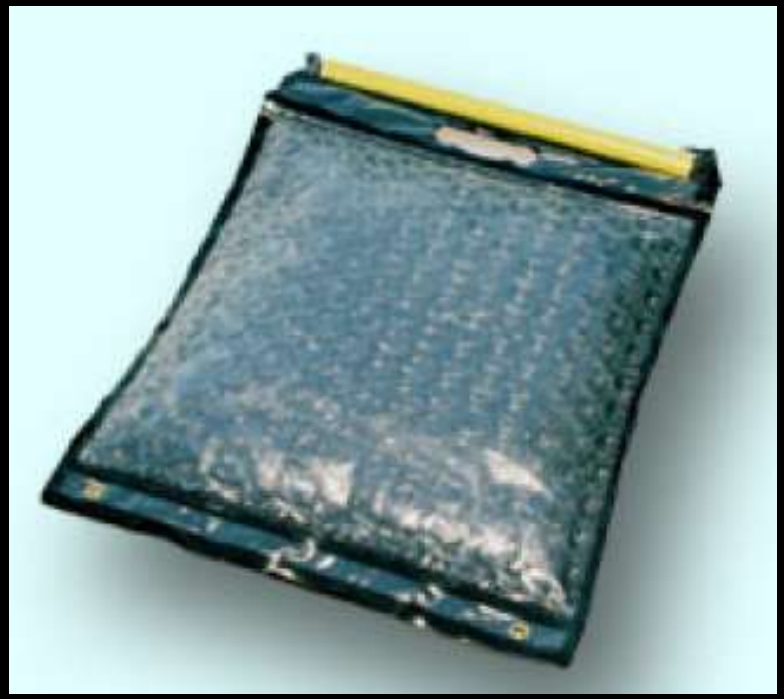
- **→ Essentially a tube which contains a soybean fat which melts at 69º C.**
- **When the fat melts, it flows down from the top to the bottom of the tube, which indicates that the water has been pasteurized.**
- **WAPI are reusable (just turn them upside down).**

WAPI

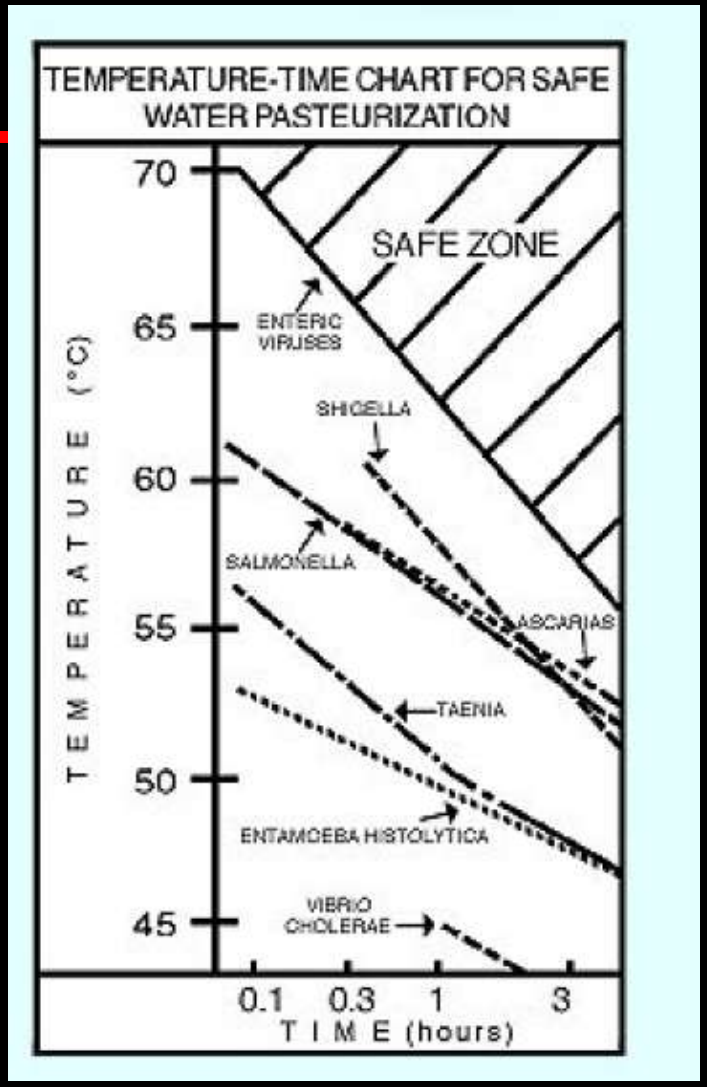
Robert Metcalf
Professor, Biological Sciences
California State University, Sacramento

AquaPak™

AquaPak, A Solar Water Pasteurizer Now Ready for World Distribution

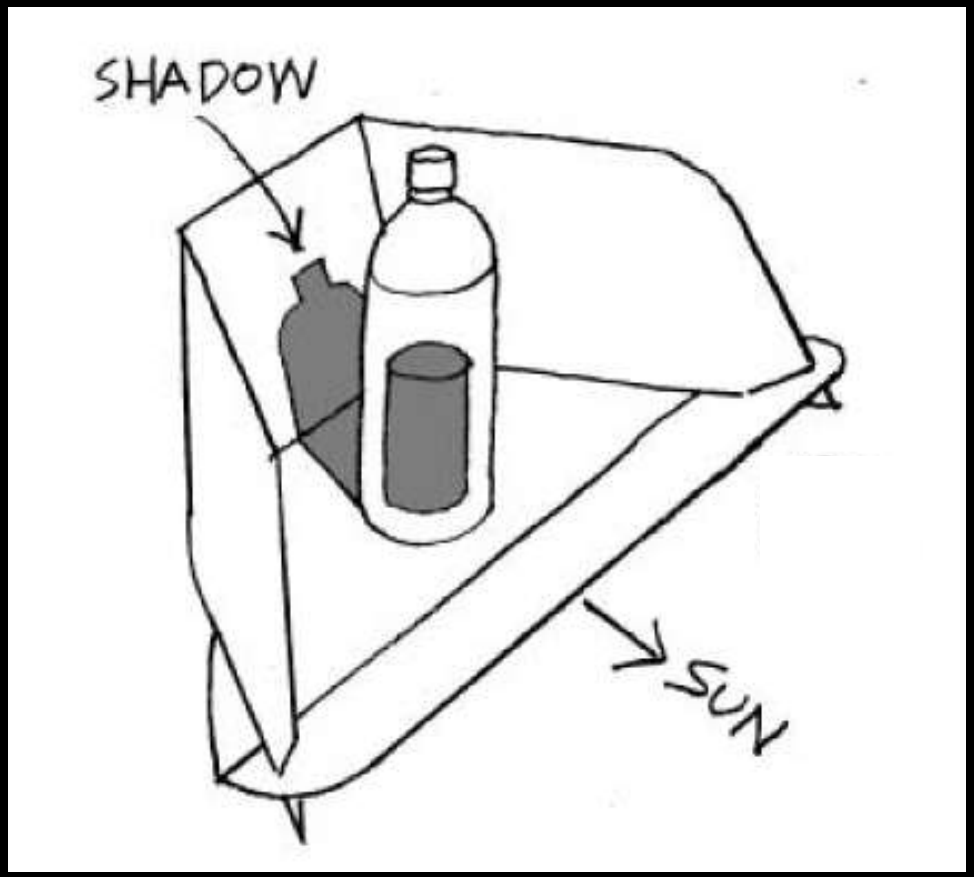


http://www.solarsolutions.info/aquapak/aquapak.html



Let's go pasteurize some water!

(http://solarcooking.org/soda-bottle-pasteurizer.htm)



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