TOT 2

Small-scale Water Treatment

# 3. Disinfection

**Saroj Sharma**

**Associate Professor of Water Supply Engineering**

**IHE Delft**

**Email: s.sharma@un-ihe.org**

**September 2021**

# Contents

- Disinfection basics and Chlorination
- Solar disinfection
- Coagulation and disinfection using chemicals

# 3.1 Disinfection basics and Chlorination

# Disinfection

- The most important requirement of drinking water is that it should be free from any microorganisms that could transmit disease to the consumers.
- Disinfection refers to the destruction or at least complete inactivation of harmful microorganisms present in the water.
- Factors influencing disinfection
  - nature and number of microorganisms present
  - type and concentration of disinfectant used
  - contact time
  - water quality (pH, temperature, turbidity of water)

# Disinfection methods

## Physical methods

- Boiling
- Solar disinfection (SODIS)
- Ultraviolet (UV) disinfection

## Chemical methods

- Chlorination (most common)
  - $Cl_2$ gas, $ClO_2$
  - Sodium hypochlorite NaOCl
  - Bleaching powder (chlorinated lime)
- Potassium permanganate
- Iodine and Bromine (solution and tablets)
- Ozone (for large-scale municipal systems only)

# Thermal Disinfection – Boiling Water

- **Effective against the full range of microbial pathogens**
- **Can be employed regardless of the turbidity or dissolved constituents of water**
- **No well accepted norms on duration of boiling;**
  **Many (including WHO) recommend bringing water to a *rolling boil***
  **(a visual indication that a high temperature has been achieved)**
- **Studies have demonstrated that heating to pasteurization temperatures (60ºC) for 10 minutes will deactivate most pathogens**
- ***Limitations***
  - **Cost of fuel and (implications on deforestation in some areas)**
  - **Smokes (adding to poor indoor air quality) & greenhouse gases**
  - **Utensils**
  - **Waiting time**
  - **Taste**
  - **Recontamination during handling**

**** Hence recommended as emergency and short-term measure**

# Chemical Disinfection – Chlorination

- Disinfection using chlorine compounds is most commonly applied in drinking water treatment.
- It is not only effective in inactivation of the pathogens but also provides residuals to take care of re-contamination, if any.
- Chlorine is available in different forms (gas, liquid, solid).
  For small-scale and household level water treatment, generally liquid or solid/powdered form of chlorine is used.
- The amount of chlorine to be added to the water depends on volume of the water to be disinfected and its quality. On-site/field test is recommended to determine the optimum chlorine dose.
- For effective chlorination, the turbidity of the water should be low and pH should be < 8.
  - Often filtration is applied before chlorination for turbid waters

# Chlorine compounds used for disinfection

| Compound | Chemical formula | Form | Typically dosed as | % Active chlorine (by mass) |
|---|---|---|---|---|
| Dilute sodium hypochlorite (Household bleach) | NaOCl | Liquid | Solution | 1 – 5 |
| Sodium hypochlorite | NaOCl | Liquid | Solution | 10 – 15 |
| Chlorinated lime (Bleaching powder) | $CaO.2CaOCl_2.3H_2O$ | Solid* | Solution | 25 – 35 |
| Calcium hypochlorite | $Ca(OCl)_2.4H_2O$ | Solid* | Solution | 60 – 70 |
| Chlor-organics | Various | Solid* | Powder or solution | 60 – 90 |
| Chlorine | $Cl_2$ | Gas or Liquid | Gas or Liquid | 100 |

*** Solid can be in the form of powder, granules or tablet depending upon the compound**

# Chlorine forms: their merits and limitations

| Chlorine Form | Merits | Limitations |
|---|---|---|
| Gas | - Low chemical cost<br>- Strong disinfectant | - Very hazardous<br>- Needs special handling equipment<br>- Needs special training to use<br>- Requires separate, well-ventilated room<br>- Emergency planning required |
| Liquid | - Easy to handle<br>- Simple injection equipment | - Requires large volume<br>- Loses strength in storage<br>- Highest chemical cost |
| Powdered | - Easy to store<br>- Simple injection equipment | - Requires mixing equipment<br>- Medium chemical cost<br>- Loses strength in storage<br>- Forms deposits on equipment |




Sodium hypochlorite solution 0.5% USP.
Use for water disinfection. Store away from sunlight and extreme heat.

**Instructions for use:**
Measure solution using the bottle lid as shown, and pour it from the lid into your water container.

For 2.5 litre container, fill outer rim of the lid.
For 5 litre container, fill outer rim of the lid twice.

For 20 litre container, fill center of the lid.


Close water container, shake container well and wait 30 minutes before using water.

**KEEP AWAY FROM CHILDREN**

Produced and distributed by SFH with support from USAID

Do not use after

# Clorin

WATER PURIFICATION SOLUTION


*PSI/Kenya SWS Product*


*The PSI SWS Product in Nigeria*


# Chlorine dose, demand and residual

- *Chlorine dose* = **amount of chlorine added to water**
- *Chlorine demand* = **amount of chlorine destroyed in the reaction with the substances present in the water**
- *Chlorine residual* = **amount of chlorine remaining in water after certain contact time**
- ***Chlorine dose*** **=** ***chlorine demand + chlorine residual***

# Determining the Chlorine Dose

1. Take 6 samples of the water to be disinfected (100 mL to 1 L)
2. Add different amount of chlorine solution or compounds in equal steps (say equivalent to 1 to 6 mg chlorine /L water)
3. Well stir the samples and leave the samples for the required contact time (say 30 minutes) in a cool place and out of direct sunlight.
4. After the contact time, measure the residual chlorine in each water sample
5. The sample with the residual chlorine in the range of 0.3 to 0.5 mg/L gives an indication of the required chlorine dose.

# Free Chlorine Test Kit, HACH Model CN-70F

# HACH Pocket Colorimeter™ II
# Chlorine (Free and Total)

# WHO Recommendations for Disinfection

## Conditions for a proper disinfection

- **Residual chlorine: ≥0.5 mg/L**
- **Contact time ≥ 30 minutes**
- **pH: < 8**
- **Turbidity: < 5 NTU; but ideally < 1 NTU**

## Residual Chlorine

*** 0.5 mg/L in water supplies after 30 minutes contact time**

*** Where there is a risk of cholera or an outbreak has occurred:**

- **At all points in a piped supply 0.5 mg/L**
- **At standposts and wells 1.0 mg/L**
- **In tanker trucks, at filling 2.0 mg/L**

*** In areas with little risk of a cholera outbreak,**
**0.2 – 0.5 mg/L at all points in the supply**

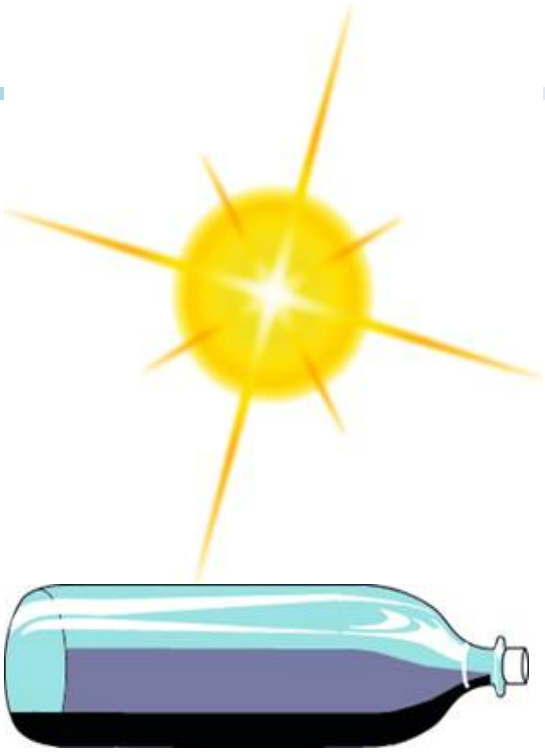
# 3.2 Solar Disinfection

# Solar Disinfection (SODIS)

- A water treatment process which utilizes on solar radiation to inactivate and destroy pathogenic microorganisms present in water
- The treatment basically consists in filling transparent containers with water and exposing them to full sunlight for about 6 hours
- Ideal and an alternative method to disinfect small quantities of water used for consumption, mainly at household level
- Does not change the chemical water quality, taste or odour of the water

# How Does SODIS Work?

- Transparent (PET) Plastic bottles or bags filled with contaminated water are exposed to full sunlight for 6 hours
- Sunlight disinfects the water by the combined effect of:
  - radiation in the UV-A spectrum
  - heating of the water
- Water temperature can rise above 50 ºC
- 3 to 4 log removal of Faecal coliforms (99.9 to 99.99%)



www.sodis.ch

# How Does SODIS Work?

**SODIS requires sun radiation and temperature:**

- **The container needs to be exposed to the sun for**
  - **6 hours if the sky is bright or up to 50% cloudy**
  - **2 consecutive days if the sky is 100% cloudy**
- **During days of continuous rainfall, SODIS does not perform satisfactorily.**
- **If a water temperature of at least 50˚C is reached, an exposure time of 1 hour is sufficient**

**SODIS requires relatively clear water (turbidity < 30 NTU).**

# How to Use SODIS ?

www.sodis.ch

1 Wash the bottle well the first time you use it

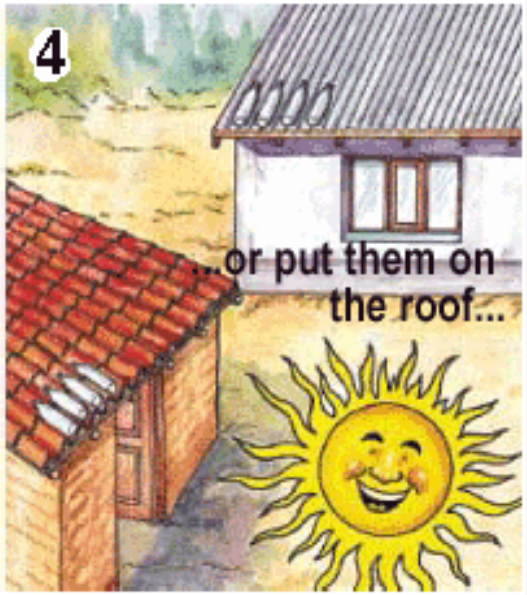
2

Now fill up the bottle fully and close the lid

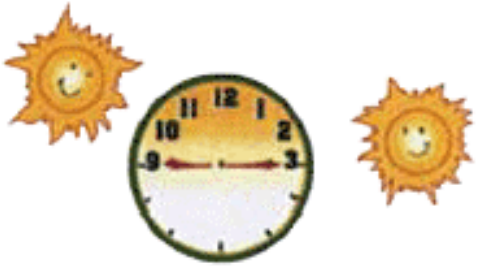
3

Place the bottles on a corrugated iron sheet

4




5



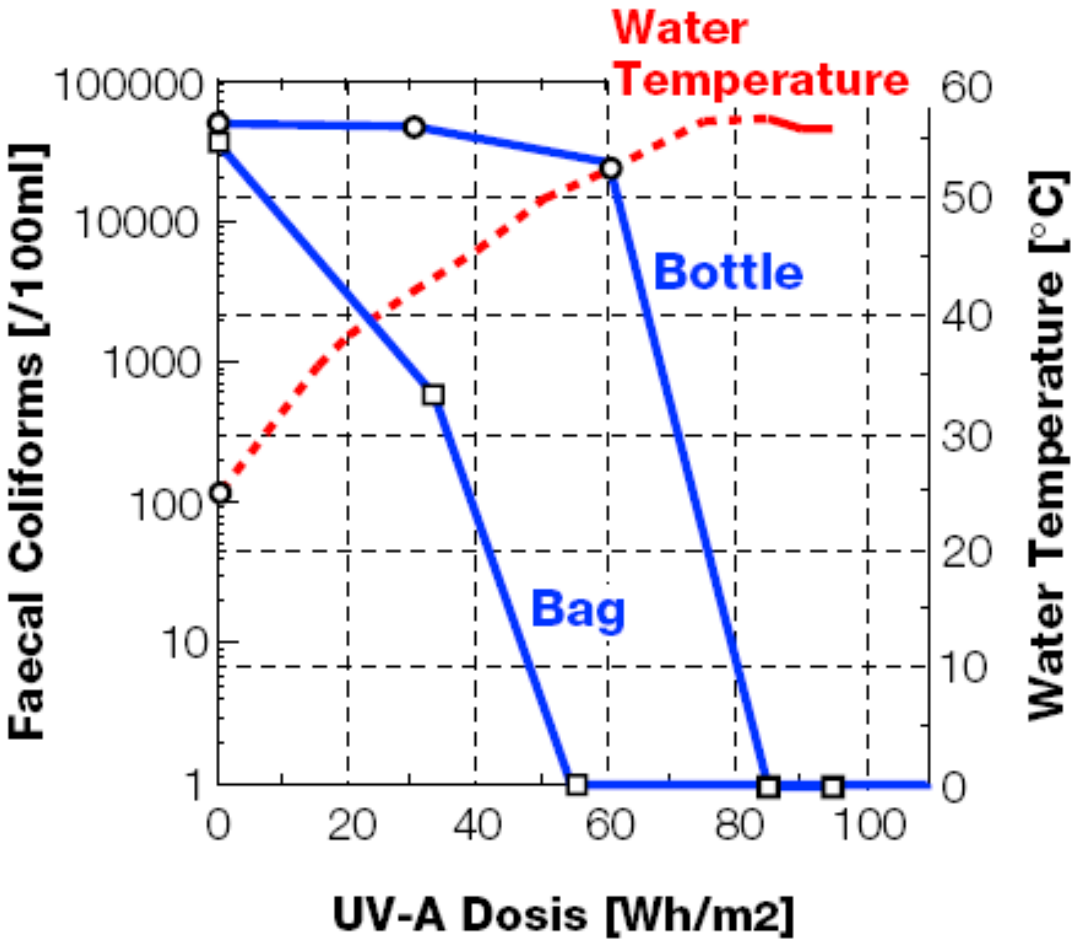
Expose the bottle to the sun from morning until evening for at least six hours

6

The water is now ready for consumption

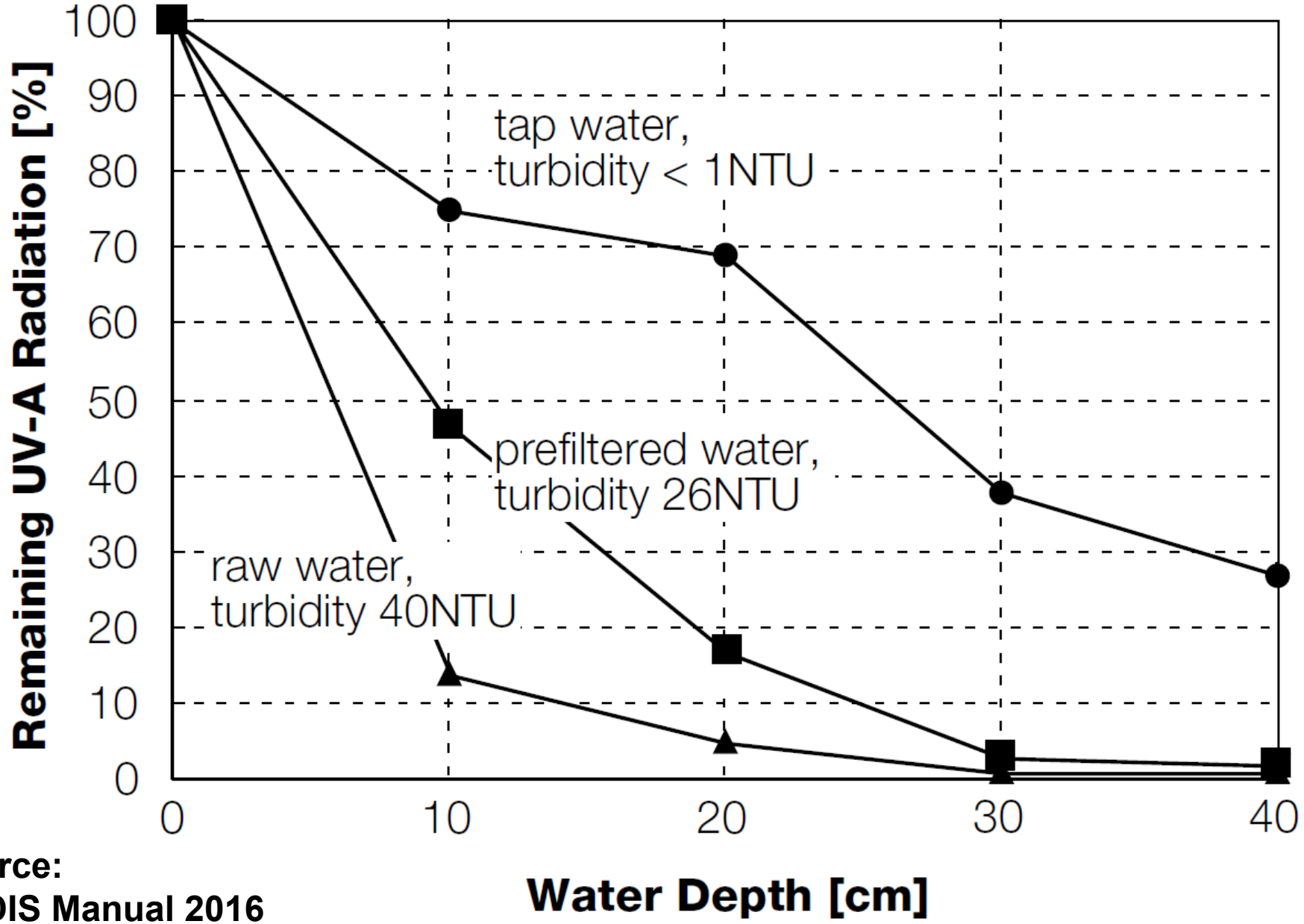
IHE DELFT

# Inactivation curves of SODIS bags and bottles




**Source: SODIS Technical Note: SANDEC - EAWAG**

# Effect of turbidity and depth on UV light penetration




**Source:**
**SODIS Manual 2016**

https://4lifesolutions.com/


# Limitations of SODIS

- **Not useful to treat large volumes of water**
- **Requires relatively clear water (turbidity < 30 NTU)**
- **Needs solar radiation (exposure time: 6 hours under bright or up to 50% cloudy sky, or 2 consecutive days under 100% cloudy sky)**
- **Requires large number of PET bottles or bags and demands high daily labour**

# *3.3 Coagulation and Disinfection using Chemicals*
## *(*PuR Purifier of Water)

# PuR Purifier of Water

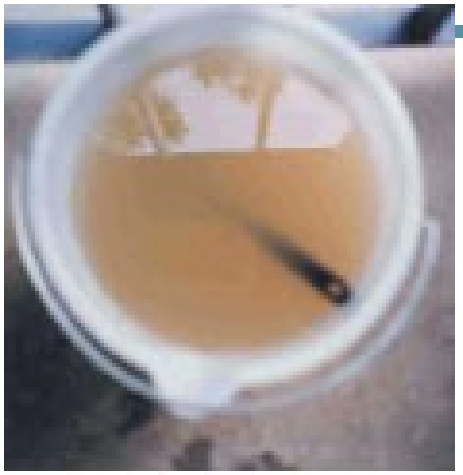
- An easy to use, effective water purifying kit, developed by Procter & Gamble
- PuR Purifier of Water packets contain powder that when mixed with water remove pathogens and cause particles to settle to the bottom of the mixing container (Flocculation + disinfection).
- The flocculant + disinfectant is a new technique combined in single use sachets to work quickly for small volumes.
- It aggregates and facilitates the removal of suspended solids, organic matter, pathogens and heavy metals.
- One packet contains enough calcium hypochlorite to leave a residual chlorine concentration of 3.5 mg/L in 10 litres of demineralised water.

# PuR Purifier of Water


## *PuR Water Purification Process*

- **Add one sachet to 10 liters of water and stir to begin process of precipitation and coagulation**
- **Stir water for five minutes until clear**
- **Filter water through a clean cotton cloth and dispose of separated floc safely (in latrine)**
- **Let clear water stand for 20 minutes to allow for complete disinfection**
- **Store in a suitable container to prevent recontamination**

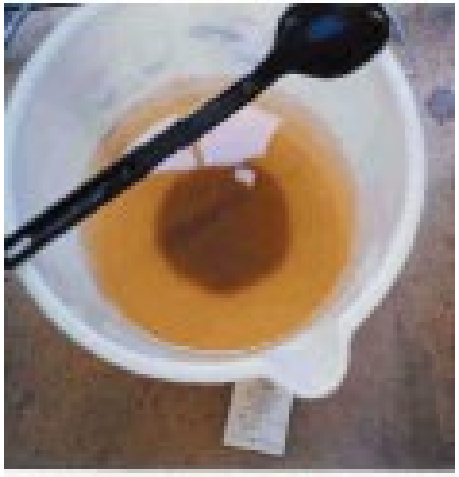
# PuR Purifier of Water



Source water

Floc formation after complete stirring

Drinkable, clear water

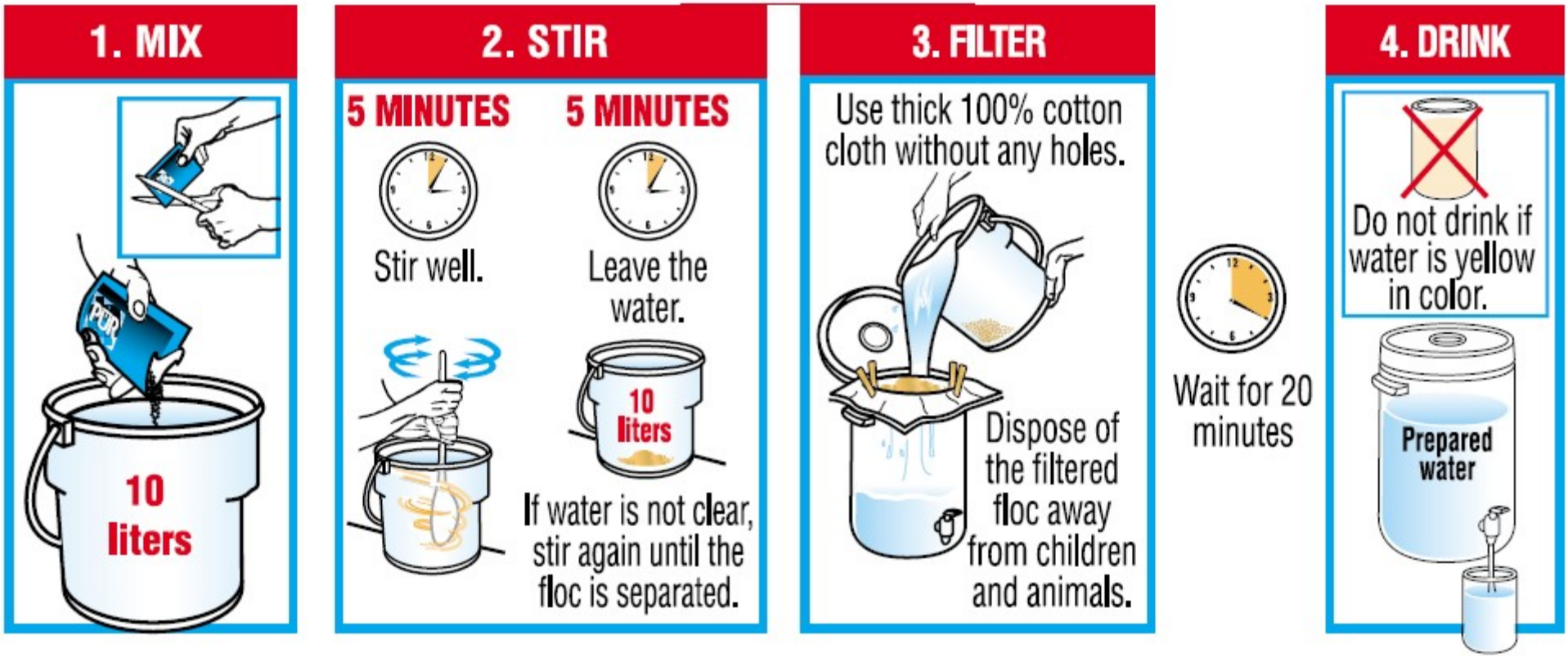


Floc formation after PuR addition

Decanting the water through a clean cotton cloth filter

http://www.pghsi.com/safewater/articles.html

# PuR Purifier of Water



TOT 2

Small-scale Water Treatment

3. Disinfection

# Thank you for your attention