2.3 Lesson 3: Water disinfection

Teacher's information – Lesson 3: Water disinfection

In this lesson, the children learn about several different water treatment methods. A discussion about the water situation at home and in school builds the link to the local context. During the practical part, the school children will come into contact with different water disinfection tools.

Homework for this lesson
- Bring water treatment tools used at home, such as bottles, chlorine solution, filters.
- Ask your parents: Do we have access to safe water at home? Do we apply a water treatment method? Which one?

Objectives – Knowledge
- Know four water disinfection methods

Objectives – Attitude
- Consider household water treatment as important for health

Objectives – Skills
- Capable of pretreating turbid water

Time
- 50 minutes

Materials – School
- Locally available water disinfection products
- 1 litre of turbid raw water
- 1 cloth and vessel or other materials for water pretreatment

Materials – Toolkit
- Images: Lesson 3

Key messages of the lesson

- **Solar water disinfection, chlorination, boiling, and filtration are water disinfection methods used at home or in school.**
- **All the methods have advantages and drawbacks.**

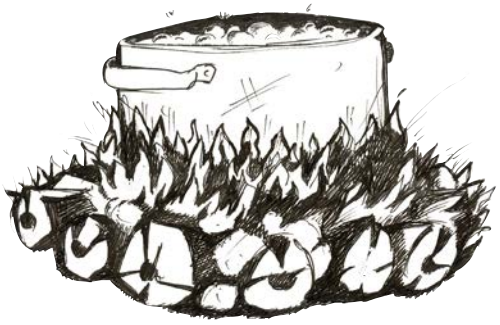
Water disinfection at home

Materials: Water disinfection products

1. Invite the children to show the water disinfection products they brought from home and start a group discussion about water disinfection.
   - Do you disinfect the drinking water at home? How? How often?
   - Do your friends or neighbours disinfect the water? How? How often?
   - Are you connected to a centralised water supply?

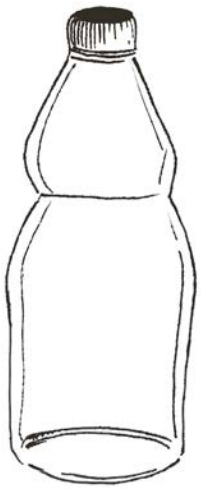
2. Inform the children about the water disinfection aims of the Safe Water School in school, at home and in the community.

3. Inform them about the concept of water disinfection.
   - Water disinfection destroys the pathogenic microorganisms in the water.
   - Water disinfection makes the water safe and prevents diseases like diarrhoea.



Vessel for boiling

Chlorine in flask



PET bottle

Overview of water disinfection methods

Images: Water disinfection

1. Explain the SODIS method and show related tools.
   - The SODIS method is very easy to apply. All it requires is sunlight and PET bottles.
   - A transparent PET bottle is cleaned with soap. The bottle is filled with water and placed in full sunlight for at least six hours. The UV-A rays in sunlight kill germs such as viruses, bacteria and parasites. The water is then disinfected and can be consumed.

2. Explain chlorination and its key steps and show related tools.
   - Chlorine is a disinfectant that kills germs such as viruses, bacteria and parasites in water.
   - Chlorine exists in tablet and liquid form or as granular powder.
   - Care should always be taken when working with chemicals.

3. Explain boiling and show related tools
   - Boiling purifies the water by heat treatment.
   - Rule of thumb: water should be brouhgt to rolling boil for one minute.

4. Explain filtration with focus on the locally available filters and show related tools.
   - Water impurities are removed with a filter by means of a fine physical barrier, a chemical or a biological process.

5. Divide the children into three groups and distribute to each group a series of images “Water disinfection”. Let the groups discuss and arrange the images in the correct order. Support the school children with finding the correct order. One child of each group hangs the series on the wall and tells the story of water disinfection.

SODIS method

Chlorination

6. Show all the water disinfection tools and explain the key advantages and drawbacks of the locally available water disinfection methods.

Good behaviour practice – pretreatment of turbid water

Materials: 1 cloth and vessel or other materials for water pretreatment

1. Demonstrate one or more locally practised water pretreatment method to reduce water turbidity.
   - Filtration, sedimentation or flocculation are pretreatment methods.
   - If the water is turbid, pretreatment is necessary for efficient functioning of chlorination, filtration or the SODIS method.

Woman filtering water

What did we learn today?

- Which water disinfection methods do you know?
- Is water turbidity important for water treatment?

Home-bringing message

- Solar water disinfection, chlorination, boiling, and filtration are different methods for water treatment at household level.
- Turbid water needs pretreatment for efficient functioning of chlorination, filtration or the SODIS method.

Homework

- Every child should bring bottles to the next lesson to treat water with the SODIS method.

2.3.1 Background information – Water disinfection

Household Water Treatment and Safe storage (HWTS)

This chapter presents the common Household Water Treatment and Safe storage (HWTS) technologies: solar water disinfection, chlorination, boiling and filtration. According to a systematic review from the World Health Organisation (WHO), household water treatment and safe storage is associated with a 39 % reduction in diarrhoeal disease morbidity.[11]

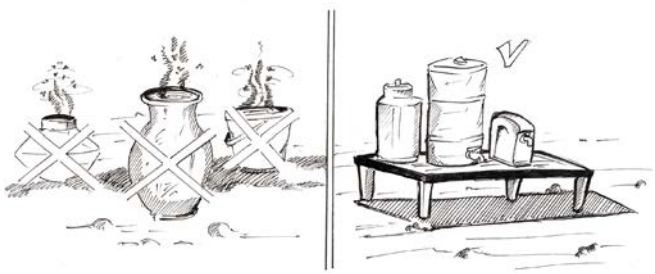
- **Solar water disinfection**
  Solar water disinfection is an effective method using solar radiation to disinfect water in PET bottles. It will be described in more detail in the chapter "Solar water disinfection" (see page 42).

- **Chlorination**
  Chemical disinfection with chlorine destroys and inactivates pathogens efficiently. It will be described in more detail in the chapter "Chlorination" (see page 50).

- **Boiling**
  Boiling water is a simple, very effective but often expensive method to sterilise water.

- **Filtration**
  Different filtration systems, such as slow sand, ceramic or membrane filters are used for water treatment. Their removal efficiencies of different chemical or microbial contamination depend on the filter material.

HWTS underlines the importance given to safe storage in water treatment. More detailed information on the appropriate vessels and correct handling of the stored water is listed in the chapter "Water recontamination" (see page 72).



Bad and good storage containers

[11] Fewtrell et al.: Water, sanitation, and hygiene interventions to reduce diarrhea in less developed countries. 2005.

Choice of HWTS technology

The choice of the most appropriate HWTS technology depends on local criteria, such as water quality at the source or cultural preferences. A combination of the different systems may be necessary to entirely remove microbial and chemical contamination. Criteria to consider when choosing a HWTS technology are:

- Effectiveness, e.g. provision of good water quality and quantity
- Appropriateness, e.g. locally available, operation and maintenance, lifespan
- Acceptability, e.g. aesthetical aspect, social status
- Cost, e.g. initial purchase, operation and maintenance, education[12]

Water turbidity

If the water is highly turbid, pretreatment is a prerequisite to render solar water disinfection, chlorination and filtration effective.

- **Cloth filtration**
  A common and easy method to reduce water turbidity is to filter it through a locally available cloth (e.g. cotton). Filtration capacity of cloth varies greatly. The cloth filters the water adequately if the dirt does not pass through the cloth. However, the cloth should not be too thick otherwise water filtering will take a very long time.

- **Sand filtration**
  Pouring water from a transport container into a container filled with sand and gravel is a simple and rapid pretreatment method. Drawback of this method are the materials required (containers and spigot).

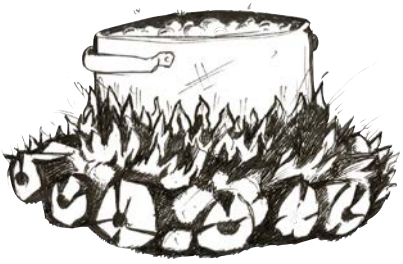
- **Coagulation and Flocculation**
  These processes agglomerate suspended solids together into larger bodies so that physical filtration processes may remove them more easily. Aluminum sulfates (alum) are an example of efficient flocculants.

- **Storage and settlement**
  Storing the water for particulates to settle to the bottom of a container is the cheapest and simplest but not very effective water pretreatment option.

[12] CAWST: An introduction to household water treatment and safe storage. 2009.

Boiling

Water boiling or heat treatment is the most traditional water treatment method. It is effective against the full range of microbial pathogens and can be employed irrespective of water turbidity or dissolved constituents in the water.



Boiling water

However, the cost and time used in procuring fuel, the potential indoor air pollution with smoke and associated respiratory infections, the increased risk of burning, and questions related to the environmental sustainability of boiling have led to the development and dissemination of other alternatives.

At sea level, boiling point is reached at 100 °C. While WHO and others recommend bringing water to a rolling boil for one minute, it is mainly intended as a visual indication that a high temperature has been achieved; even heating to 60 ºC for a few minutes will kill or deactivate most pathogens. Ideally, the water is cooled, stored in the same vessel and covered with a lid to minimise the risk of recontamination.

Advantages

- Common technology
- Complete disinfection if applied with sufficient temperature and time
- Can be combined with cooking and tea boiling

Drawbacks

- Boiled water tastes flat
- Expensive (fuel, fire wood, gas etc.)
- Time consuming (physical presence needed during heating process, long cooling time)
- Chemical contaminants are not removed

Filtration

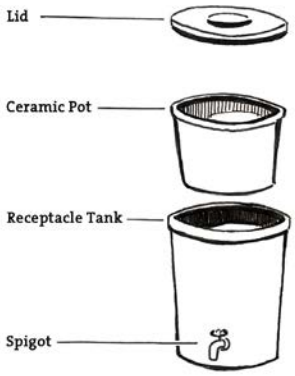
A number of processes occur during filtration, including mechanical straining, absorption of suspended matter and chemicals as well as biochemical processes. Depending on the size, type and depth of the filter media, as well as on the flow rate and physical properties of the raw water, filters can remove suspended solids, pathogens, certain chemicals, tastes, and odours.

Ceramic filter

Water is filtered through a candle or pot made of porous material, usually unglazed ceramic. The ceramic filters' effectiveness depends on the size of the pores in the clay.

To use the ceramic filters, people fill the top receptacle or the ceramic filter with water that flows through the ceramic filter into a water storage receptacle.

The treated and stored water is accessed via a spigot on the water storage receptacle.



Elements of a ceramic filter

Advantages

- Proven reduction of bacteria and protozoa
- Proven reduction of diarrhoeal disease incidence in users
- Neither chemicals nor fossil fuels required
- Simple installation and operation
- Turbidity removed
- No change in water taste or odour

Drawbacks

- Candles and pots are fragile
- Low effectiveness against viruses
- Small fissures and cracks may lead to reduced removal of pathogens
- No residual disinfection effect (risk of recontamination)
- Regular cleaning of the filter and receptacle is necessary
- Not applicable with extremely turbid water

BioSand filter

The BioSand filter is a technological adaptation of the century old slow sand filtration process and suited for home use. In slow sand filtration, the water flows slowly (flow velocity of 100 - 200 l/m²/h) downwards through a bed of fine sand.

BioSand filter

The most widely used version is a concrete container approximately 90 cm high and 30 cm wide filled with sand.

The water level is maintained at 5 - 6 cm above the sand layer by adjusting the height of the outlet pipe. This maintains the water level always above the sand and leads to the formation of a biologically active layer called “Schmutzdecke”.

A perforated plate on top of the sand prevents disruption of the bioactive layer when water is added to the system.

After pouring water into the BioSand filter, it is purified by the following four processes:

- mechanical trapping (sediments, cysts and worms get trapped between the sand grains)
- adsorption or attachment (viruses are adsorbed or become attached to the sand grains)
- predation (microorganisms consume pathogens found in the water)
- natural death (pathogens die because of food scarcity, short life span)[13]

Advantages

- Proven removal of protozoa and about 90 % bacteria
- One-time installation with few maintenance requirements
- Long life, durable and robust
- Easy to use
- Removes turbidity, some iron, manganese and arsenic
- Water quality improves with time
- Opportunity for local business

Drawbacks

- Low rate of virus inactivation
- Lack of residual protection and removal of less than 100 % bacteria
- Difficult to transport and high initial costs
- Continuous use of the filter required
- Difficult to use in highly turbid water

[13] Lantagne et al.: Household water treatment and safe storage options in developing countries. 2005.

Membrane filter

Gravity Driven Membrane (GDM) filtration removes all types of pathogens by ultrafiltration. Most ultrafiltration membranes have pores, which are smaller than the size of bacteria and viruses. Water filtered through these membranes is microbiologically safe. GDM filtration works with flux stabilisation. Pressure necessary to press water through the membranes is generated by gravity created by differences in water levels between two storage tanks. As a feed, natural water (river, spring, well or rainwater) can be used without pre- or post-treatment.

Neither pumps nor chemical cleaning or backflushing are necessary. Thus, no maintenance is required for long-term operation. A 40 – 60 cm water column is sufficient to operate the system using 0.5 m^2 of membrane to produce at least 50 litres of safe drinking water per day.

Advantages

- Easy to operate
- No electricity required
- No need to backwash or clean the filter
- No recurring costs (e.g. chemicals)
- Effective against bacteria and viruses
- Applicable on highly turbid water

Drawbacks

- Equipment not always available
- Relatively expensive
- Still under development