2.5 Lesson 5: Chlorination

Teacher's information – Lesson 5: Chlorination

In everyday school life, production of chlorine and water treatment with chlorine are carried out by the members of the Safe Water Club. However, it is important that all children get familiar with this most commonly used disinfection method. They learn therefore in this lesson about water chlorination and practise the use of liquid chlorine to treat water.

Preparation
- Produce 0.5-litre of liquid chlorine solution.

Homework for this lesson
- Every child should bring chlorine products to the lesson.

Objectives – Knowledge
- Understand chlorination, its advantages and drawbacks
- Know different types of chlorine
- Know the different steps of chlorination with liquid chlorine

Objectives – Attitude
- Consider chlorine as a useful method for water treatment

Objectives – Skills
- Capable of chlorinating 20 litres of water
- Capable of recognising when water is too turbid for chlorination
- Capable of finding chlorinated water in school for drinking purposes

Time
- 60 minutes

Materials – School
- 60 litres of water from a source used for drinking
- 0.5 litre of liquid chlorine solution produced in school
- Chlorine in different forms (locally available types)
- Drawing material

Materials – Toolkit
- 3 jerrycans (20 litres)
- 1 syringe
- WataBlue kit for residual chlorine measurement
- User guide "Use of active chlorine concentrate"
- Images: Lesson 5

Key messages of the lesson

- **Chlorine is the most commonly used chemical disinfectant worldwide.**
- **Getting the correct dosage of chlorine ensures a good water taste.**

Water disinfection with chlorine

Materials: Chlorine in different forms
Images: Chlorination

1. Show the images “Chlorination” and introduce chlorination.
   – Chlorination consists in adding chlorine to water to purify it.
   – Chlorine is left for 30 minutes in the water to allow reactions with the germs.
   – Chlorine is the most commonly used disinfectant worldwide.
   – It is an effective method as it kills 99 % of germs such as viruses, bacteria and parasites.

Disinfecting water with chlorine

Drinking safe water

2. Invite the children to present the chlorine products they brought from home.
   – Who uses chlorine products at home?
   – How often do you use chlorine at home?

3. Explain the use of the different chlorine products.
   – Chlorine can be found in different forms, such as tablets, powder granules or liquid solution.
   – Liquid chlorine can be produced with a simple device using only salt and water.
   – Since its use depends on the product, it is important to read the instruction of each product before using chlorine.

Chlorination - step-by-step

Materials: 0.5 litre of liquid chlorine, 1 jerrycan (20 litre), 1 syringe, User guide "Use of active chlorine concentrate"

1. Demonstrate how to use liquid chlorine to treat water according to the steps in the user guide "Use of active chlorine concentrate".

Labelled chlorine solution

2. Show the children the container with 0.5 litre of liquid chlorine and explain the importance of labelling.
   - Liquid chlorine is properly labelled with the concentration, the date of production and the date of expiry.

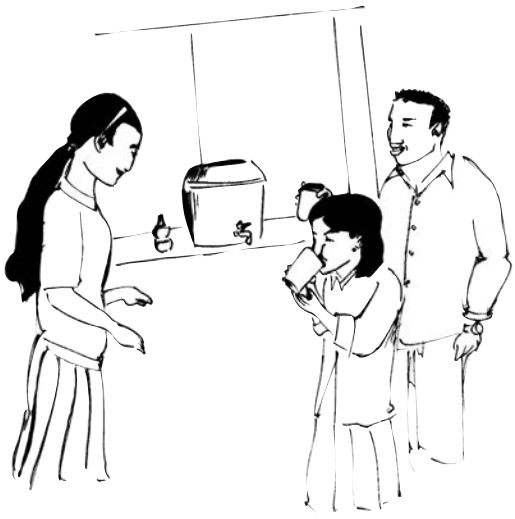
3. Take a 5ml-sample of chlorine with a syringe.
   - The amount of chlorine depends on type and concentration of chlorine.
   - 5 ml of chlorine concentrate produced with the Mini-Wata will be enough to treat 20 litres of water.

4. Add the chlorine to the clear water in the 20-litres jerrycan
   - Before treating with chlorine, the water must be clear.
   - Test turbid water with a 60 cm high bottle. If water is turbid, filter it.

5. Shake the container vigorously and rinse the syringe with water.

6. Explain that water is ready for consumption in 30 minutes.
   - The chlorine destroys all microbes in 30 minutes.
   - Chlorine hinders recontamination. Properly stored, the water remains safe.

7. Present the advantages and drawbacks of chlorination in the local context.



Family drinking chlorinated water

Good behaviour practice – chlorination

Material: 0.5 litre of liquid chlorine, 2 jerrycans (20 litres), User guides "Use of active chlorine concentrate" and "WataBlue reagent kit", drawing material

1. Ask the children to smell the liquid chlorine and explain the precautions to be taken.
   - The smell of chlorine is very strong.
   - Do not drink from this bottle. It is not toxic but it will taste very bad.
   - Do not spill it on your clothes as it acts like a bleach.

2. Look together with the children for an easily accessed place to install the jerrycans in the school.

3. Get the schoolchildren to practise with two jerrycans of water according to the steps in the user guide "Use of active chlorine concentrate".

4. Wait 30 minutes and test the presence of free residual chlorine with WataBlue according to the steps in the user guide "Wata-Blue reagent kit".

5. Discuss the results and ask the children to smell and drink the treated water.
   - Can you smell the chlorine?
   - Is the water safe now?

WataBlue test

6. Ask them to write three times "Chlorinated water" on a piece of paper and stick it to the jerrycans.

7. Store chlorinated water safely for the water quality test in the next lesson (see page 66).

What did we learn today?

- What do you think happens to the germs when chlorine is added to the water?
- Why does chlorine hinder recontamination?
- What are the five steps of the chlorination method?
- What do we do if the water we are using for chlorination is turbid?
- Why is it important to wait for 30 minutes before drinking the chlorinated water?
- How much liquid chlorine do you put in a 20-litre jerrycan?
- Where can you find chlorinated water in school?

Home-bringing message

- Explain or demonstrate the chlorine method.
- Optional: Show the chlorination painting.

2.5.1 Chlorine production – Lesson for Safe Water Club

Teacher's information – Lesson for Safe Water Club

This lesson is dedicated to the Safe Water Club which is responsible for producing liquid chlorine solution, treating water for the school, keeping log-books and maintaining the equipment. For each step of the of the chlorine production, practical exercises are essential. One person is practising at the front and the other participants give their comments. All the steps to produce chlorine should be repeated several times so that the Safe Water Club can become acquainted with the chlorine production.

Preparation
- Read the lesson with background information on chlorination
- Read the four Mini-WATA user guides
- Prepare 0.5 litre of liquid chlorine at 6 g/l and three water samples with different amount of chlorine (no chlorine, right amount of chlorine, too much chlorine)

Objectives – Knowledge
- Understand chlorination, its advantages and drawbacks
- Know the five steps of chlorine production with the Mini-WATA

Objectives – Attitude
- Confident with the production and use of chlorine with the Mini-WATA
- Consider the Mini-WATA kit and solar panel as valuable equipment

Objectives – Skills
- Capable of producing chlorine with Mini-WATA and keeping logs of chlorine production
- Capable of maintaining the equipment for chlorine production
- Capable of treating water in school with chlorine

Time
- 6 hours

Materials – School
- 0.5 litre of liquid chlorine at 6 g/l produced in advance
- 3 water samples with different amounts of chlorine
- 3 jerrycans (20 litres)
- 60 litres of water from a source used for drinking
- Log-book to record chlorine production
- Paper and pen

Materials – Toolkit
- 1 Mini-WATA kit
- 1 solar panel
- Mini-WATA user guides

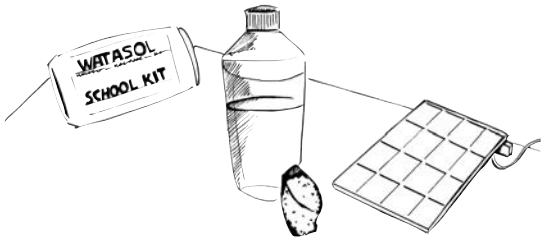
Mini-WATA

Materials: 1 Mini-WATA kit, 1 solar panel

Mini-WATA

1. Explain the Mini-WATA.
   - The Mini-WATA is a small device that produces liquid chlorine.
   - It requires only clear water, salt and an external power source.
   - The Mini-WATA fits snugly into a 0.5-litre plastic bottle.
   - It produces 0.5 litre of chlorine concentrate in five hours, enough to treat up to 2 000 litres of water.

2. Present the Mini-WATA kit materials in class and explain the two options for power supply.
   - The Mini-WATA is supplied with clips that can be coupled to a solar panel of min. 10 watt.
   - If there is access to electricity, the Mini-WATA is supplied with a transformer that can be simply plugged into the network.



Mini-WATA kit, water, salt and solar panel

3. Make children touch and manipulate the device and explain the advantages of the Mini-WATA.
   - Simple – you only need water and salt
   - Robust – it does not break easily
   - Low cost – salt and water do not cost much
   - Independent from external suppliers
   - Production at source avoids transport and storage isues

Overview – Chlorine production and water treatment

Materials: User guides "Mini-WATA (solar and electric power supply)", "WataTest reagent kit", "Use of active chlorine concentrate" and "WataBlue reagent kit"

1. Explain that five steps are needed to treat water using a chlorine solution produced by the Mini-WATA. Show the four user guides and insist on the importance of following them during every step. No need to learn by heart!
   - Step 1: Produce chlorine
   - Step 2: Test the chlorine concentration with WataTest
   - Step 3: Treat water by adding chlorine
   - Step 4: Test free residual chlorine with WataBlue
   - Step 5: Water is safe to drink!

Step 1: Produce chlorine

Materials: User guide "Mini-WATA"

1. Choose with the children a production place which is cool, ventilated and shielded from sunlight.

2. Explain the function of saturated brine for the the production of liquid chlorine. Demonstrate the preparation of saturated brine according to the user guide "Mini-WATA" and label the saturated brine.
   - Saturated brine is a water with the maximum possible amount of salt.
   - It helps to dose the correct amount of salt to produce chlorine.
   - It can be stored forever and reused but make sure that there is always salt remaining at the bottom of the container.

3. Ask one of the children to practise preparation of saturated brine and ask the others to comment.

4. Demonstrate the production of chlorine according to the user guide "Mini-WATA".
   - Chlorine concentrate can be produced either with a solar panel or with the grid.
   - The Mini-Wata produces 0.5 litre of chlorine concentrate in five hours.
   - As soon as the Mini-WATA is connected to the power supply, bubbles will emerge from the container. This means the process is working!

5. Hand out a log-book (see page 114) to record chlorine production and ask the children to designate someone to fill it in.

6. Ask one of the children to practise the chlorine production and ask the others to comment.

7. While the Mini-WATA is running, talk with the children about the maintenance of the Mini-WATA, the shelflife and safety of chlorine.
   - Maintain the Mini-WATA by rinsing with clear water after each use and not letting it run for ten hours in a row.
   - Use active chlorine within 24 hours of its production.
   - Chlorine is safe if the following points are considered: Do not inhale the concentration. Work in a well ventilated area. Never use a metallic container during the procedure. Do not drink the concentrated solution. Do not spill it on your clothes as it has bleaching power.

8. In order not to wait five hours until the chlorine production is completed, proceed with the next step and leave the production running. Come back to it when the five hours are over.

Step 2: Test the chlorine concentration with the WataTest

Materials: User guide "WataTest", 0.5 litre of liquid chlorine, paper, pen

1. Explain and demonstrate how to test the chlorine concentration with the WataTest according to the user guide "WataTest". Use the 0.5 litre of chlorine produced in advance.
   - The Mini-WATA produces a solution with 6 g/l of chlorine.
   - It is important to test the solution to make sure the concentration is right.
   - The WataTest measures the chlorine concentration.

2. Explain the results of the WataTest.
   - The number of drops divided by two gives you the chlorine concentration.
   - 12 drops show a chlorine concentration of 6 g/l.

3. Ask one of the children to practise the procedure and ask the others to comment.

4. Explain and demonstrate the proper storage of the chlorine in an opaque plastic container.

5. Explain the importance of labelling the container with the concentration of chlorine obtained, the production and expiry date. Ask one child to prepare a label and stick it on the container with chlorine concentration.

6. Choose with the children a storing place which is cool and shielded from sunlight and store the container properly.

Labelled chlorine solution

Step 3: Treat water by adding chlorine

Materials: User guide "Use of active chlorine concentrate"

1. Explain and demonstrate the treatment of water by adding chlorine according to the user guide "Use of active chlorine concentrate". Repeat the activity "Chlorination – step-by-step" from lesson "Chlorination" (see page 52).

2. Ask one of the children to treat the water of a 20-litre jerrycan by adding chlorine and ask the others to comment.

Step 4: Test free residual chlorine with WataBlue

Materials: User guide "WataBlue", 3 water samples with different amounts of chlorine

1. Explain the concept of free residual chlorine.
   - Free residual chlorine stops the water from becoming recontaminated.
   - It indicates that enough chlorine was used to treat the water.
   - The amount of free residual chlorine depends on the water contamination.
   - Very contaminated water needs more chlorine.

2. Present the three water samples to be tested. Ask the children to describe how they smell.
   - Sample 1: Not enough chlorine
   - Sample 2: Too much chlorine
   - Sample 3: Right amount of chlorine

WataBlue test

3. Explain the test of free residual chlorine with WataBlue according to the user guide "WataBlue". Demonstrate the WataBlue-Test with the three examples. Use new pipettes for each sample to avoid contamination.
   - A white sample indicates that there is not enough chlorine in the water.
   - A light blue sample indicates the right amount of chlorine to hinder recontamination.
   - A dark blue sample indicates that too much chlorine was added and water will have a bad taste.

4. Ask the children to identify the sample with the right amount of chlorine.

5. Ask one of the children to practise the procedure and ask the others to comment.

Step 5: Water is safe to drink

Materials: Cups

1. Taste the water with the children.
   – Congratulations you have safely produced a concentrated chlorine solution and treated your water with it.

2. After five hours, go back to the production site. Ask one child to check the chlorine concentration with the WataTest. Label it and store it properly. Rinse the Mini-WATA with clear water and store all the materials in a secure place.

Drinking safe water from a clean glass

Chlorinated water in school

1. Discuss the amount of drinking water needed in school based on two litres per person and day. Calculate the amount of chlorine needed.

2. Organise the production of chlorine. Designate a person of the Safe Water Club responsible for maintenance, equipment and keeping logs of chlorine.

What did we learn today?

- How does the Mini-WATA work?
- What are the five steps for chlorine production and water treatment?
- What precautions have to be taken to make chlorine production safe?
- Why is the WataTest important?
- How to you know that water is safe to drink?

Home-bringing message

- Advantage of local chlorine production: The quality of chlorine produced is ensured. It is independent from external supply and can be produce on demand.

2.5.2 Background information – Chlorination

Chlorine is the most commonly used disinfectant worldwide. It is an effective method capable of killing 99% of germs such as viruses, bacteria and parasites. Chlorine can be found in different forms such as tablets, powder granules and liquid concentrated solutions. It can also be produced locally.

Chlorination is a method of water purification to make it safe for human consumption. It is left for 30 minutes in water to allow reaction with the germs. Before treating with chlorine, the water must be clear. After treatment with chlorine, the presence of residual chlorine in drinking water indicates that the water is protected from recontamination during storage.

Chlorine production is safe if you stick to the following rules:

- Do not inhale the concentrate over a long period
- Work in a well ventilated area
- Never use a metallic container during the procedure
- Do not drink the concentrated solution (it is not toxic but it will taste very bad)
- Do not spill it on your clothes as it is a bleach

Advantages

- Most widely used disinfection method worldwide
- Powerful and effective
- Reliable, kills 99 % of all pathogens
- Proven health impact
- Easy to use
- Residual chlorine prevents recontamination
- Low cost
- Rapid method: only 30 minutes are needed
- Treats large water volumes

Drawbacks

- Requires relatively clear water
- Alters taste and odour of water
- Not effective against chemical contamination
- Lower protection from some organisms (cryptosporidium)
- Concentrated chlorine solutions require careful handling
- Dosage is considered as a main challenge
- Not always available locally

Mini WATA

The Mini-WATA is a small device that produces liquid chlorine at 6 g/l. It requires only clear water, salt, an external power source and works according a process called electrolysis. The Mini-WATA fits snugly into a small plastic water bottle of 0.5 litre. It produces 0.5 litre of chlorine concentrate in five hours, enough to treat up to 2 000 litres of water.

Mini-WATA and a 0.5-litre water bottle

The Mini-WATA can be coupled with a photovoltaic panel of minimum 10 watt. It is furnished with clips for a solar panel. If you have access to electricity, the Mini-WATA is supplied with a transformer that can be simply plugged into the network (110 V or 220 V).

In chapter “Water treatment station” there is information about the required materials (see page 88). It is a valuable equipment. Appoint a responsible person to look after the materials and their careful storage in a secure place.

Advantages

- Simple and robust
- Easy to use: requires only clear water, kitchen salt and any source of electric current
- Low cost: cost of chlorine produced is cheaper than the one found on the market
- Independent from external suppliers
- Production at source avoids transport and storage issues
- Quality control check with WataTest and WataBlue

Overview – Chlorine production and water treatment

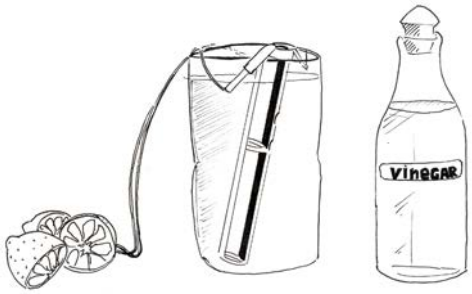
Five steps are needed to treat water using a chlorine solution produced by the Mini-WATA. The steps refer to a specific user guide listed in the appendix (see page 108).

- Step 1: Produce chlorine – User guide “Mini-WATA”
- Step 2: Test the chlorine concentration with Wata-Test – User guide “Wata-Test”
- Step 3: Treat water by adding chlorine – User guide “Use of active chlorine concentrate”
- Step 4: Test free residual chlorine with WataBlue – User guide “WataBlue”
- Step 5: Water is safe to drink!

Step 1: Produce chlorine

Follow the procedure described in the user guide “Solar and Electric Mini-WATA”.

- **Maintenance**
  Rinse the Mini-WATA with clear water after each use. Do not use soap. Dip it in a solution of water and vinegar or lemon for one night when there is too much white deposit on it. Do not let it run for more than ten hours in a row. Clean the solar panel with a cloth and water to remove dust.



Clean Mini-WATA in a solution of water and lemon or vinegar

Clean solar panel with water and a cloth

- **Shelflife of chlorine**
  Use active chlorine within 24 hours of its production. The concentration of active chlorine decreases with time. High temperature affect the stability of chlorine. You should measure its concentration with Wata-Test before proceeding to treat water.

- **Rain**
  During rainy periods, the solar panel will not have enough energy to make the Mini-WATA work. Stop production, store all the materials in a proper place and start again when it is sunny. The process of chlorine production can be restarted. If you produce for two hours one day, the next day three hours will be sufficient to obtain the total of five hours needed.

Step 2: Test the chlorine concentration with Wata-Test

Follow the procedure described in the user guide “Wata-Test”.

- **Importance of WataTest**
  Mini-WATA reliably produces 0.5 litre of chlorine at 6 g/l after five hours. However, the concentration may vary due to initial water quality, dosage and quality of salt, electrical supply quality, reaction time, and environment. It is thus important to check the chlorine concentration after each production. WataTest is a non toxic reagent used to check the chlorine concentration produced.

- **Adapting**
  If the strength is below 5 g/l, connect the Mini-WATA to the solar panel or the grid and continue the process. If it is 5.5 g/l or higer than 6 g/l adapt the dilution according to the table:

Chlorine concentration in g/l	Amount of chlorine to be added (20 litres)
5.5	5.50 ml
6	5.00 ml
6.5	4.60 ml
7	4.28 ml

- **Chlorine storage and labelling**
  After each production, store chlorine in an opaque plastic container and label it with the concentration of chlorine obtained and date of production and expiry. Place the container in a cool place away from sunlight.

Step 3: Treat water by adding chlorine

Follow the procedure described in the user guide “Use of active chlorine concentrate”.

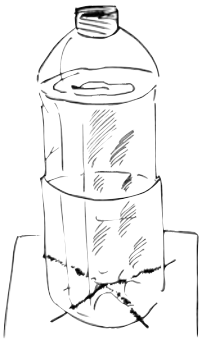
- **Water treatment with chlorine**
  The quantity of chlorine concentrate necessary for water treatment depends on the initial water quality. For water of average quality, 0.25 ml of chlorine produced with Mini-WATA is needed for every litre of water to be treated.

- **Adapting**
  Adapt the amount of chlorine to be added to water according to the locally available vessels.

- **Turbidity**
  For effective disinfection, water must be clear with low turbidity, less than 5 NTU.

  If you do not have testing equipment, draw a small black cross on a white piece of paper and put a large bottle (60 cm tall) full of water on top of it. To get 60 cm tall bottle, take two PET bottles and cut the first one horizontally slightly below the level of the tap. Take the second bottle, cut the bottom of the bottle in order to fit it into the first one. Fill it with water. You have a 60 cm tall bottle!

  If you can see the cross, the water is clear enough. If you cannot see the cross, filter the water before adding chlorine.



Turbidity test with two bottles

Cloth filtration for turbid water

Step 4: Test free residual chlorine with WataBlue

Follow the procedure described in the user guide “WataBlue”.

- **Chlorine demand**
  The amount of chlorine needed to eliminate the germs in the water is called the chlorine demand. Chlorine demand depends on the source and quality of the water: the dirtier the water, the more chlorine is needed.

- **Free residual chlorine**
  The amount of chlorine left over after 30 minutes is called free residual chlorine. The correct amount of residual chlorine shows that the water is treated and can be drunk. Water is protected from recontamination. Measure it after every treatment with chlorine. The ideal concentration of free residual chlorine in water is between 0.5 ppm to 1 ppm (parts per million).

- **Testing for free residual chlorine using WataBlue**
  WataBlue, a non toxic reagent, is one of several methods to measure free residual chlorine in water treated with chlorine.

- **Storage of water**
  The treated water should be stored in a clean and closed container.

Step 5: Water is safe to drink!

The water is now ready for consumption. Chlorine prevents from recontamination. Properly stored the water stays safe.