



60 minutes total

Lesson Plan 04 Aspects of Drinking Water Quality

Overview of Activities

1. Introduction
2. Aspects of Drinking Water Quality (DWQ)
3. Microbiological Aspects
4. Chemical Aspects
5. Acceptability and Radiological Aspects
6. Review

Learning Outcomes

At the end of this session participants will be able to:

1. List the four aspects of DWQ
2. Identify different types of pathogens
3. Describe microbiological indicator organisms
4. Examine the impacts of priority chemicals on drinking water
5. Discuss the factors that affect the acceptability of drinking water

Materials & Preparation

- PowerPoint: Aspects of Drinking Water Quality (DWQ)
- Activity: Information Treasure Hunt
- Prepare: Print Chemical Parameter Fact Sheet posters, (see end of lesson) Arsenic, Fluoride, Nitrate, Chlorine, Iron, Manganese, pH, TDS (eight pages)
- Handout: Chemical Parameters Clues (see end of lesson) (one page; one copy per participant)
- Bottle or glass of water
- Activity: Prepare paper cabbage activity (see instructions below under Review)
- Prepare: Cue music on computer or phone for the paper cabbage review

Recommended Reading

- Technical Brief: Aspects of Drinking Water Quality
- Chemical Fact Sheets (CAWST WASH Resources)

5 minutes

Introduction



1. Ask: “We talked about the main categories of drinking water quality in the previous session. What are they?”
 - Microbiological
 - Chemical
 - Acceptability (or Physical)
2. Explain: “These categories are called Aspects of Drinking Water Quality.”
3. Explain: “The World Health Organization (WHO) classifies water quality aspects into four groups. You have identified three categories. Do you know what the fourth category is?”
 - Radiological
4. Explain: “This lesson examines the aspects of drinking water quality in greater detail.”
5. Present the learning outcomes or an overview of the lesson.

15 minutes

Microbiological Aspects



Use PowerPoint: Aspects of Drinking Water Quality for this presentation (optional).

1. Ask: “What is a pathogen?” Display the definition of a pathogen.
 - “A microorganism that causes disease”
(not all microorganisms are pathogens)
2. Ask: “What are the four types of microorganisms?”
 - Virus
 - Bacteria
 - Protozoa
 - Helminths (worms)
3. Either use the PowerPoint slides or printouts to show the four types of microorganisms, their relative sizes, examples and descriptions of each type.
4. Ask: “How many different kinds of pathogens are found in water?”
Follow up with asking if they know what organisms would be tested for in water from their local water source. Responses will vary.
5. Explain that testing for every possible pathogen in water is time-consuming, complicated, and expensive. Since most disease-causing pathogens come from feces it is more practical to test for signs of feces in water.
6. Ask: “How can you test for feces in water?”
 - Microorganisms whose presence in water indicates the likely presence of feces, and possibly, pathogens
 - Indicator bacteria are usually used to test for fecal contamination

7. Explain that the two main bacterial indicators used for water quality testing are E. coli and thermotolerant (TTC) coliforms.
8. Use the PowerPoint slides to show the Comparative Diagram of Bacterial Subgroups to illustrate: E.coli, thermotolerant coliforms and total coliforms.
9. Ask: “What is the recommended WHO guideline for microbiological contamination in drinking water?”
 - The WHO Guidelines recommend that drinking water should have zero fecal contamination in any 100 ml sample.
10. Use the PowerPoint slides to display and discuss the Risk for Fecal Contamination in the Drinking Water table.

Key Points

- The presence of bacterial indicators in a water sample is not an absolute indicator for the presence of pathogens in the water. Rather it means that the water was likely contaminated with feces and is at a higher risk for causing disease.
- Bacterial indicators in water do not always link to the presence of protozoa, helminths or viruses.

11. Say: “Time for a stretch break!”
 - Divide the participants into four groups
 - Ask each group to make an action or dance move for one of the pathogen types
 - Get all groups to share their actions with the other participants
 - Then do all the actions as a full group, moving from the smallest to the largest pathogens

15 minutes

Chemical Aspects



1. Activity: Information Treasure Hunt
2. Post the Chemical Fact Sheet posters around the room, as far apart as practical, to give room for participants to move around freely.
3. Explain: “The posters have important information about key chemical parameters related to drinking water quality.”
4. Hand out the Chemical Parameter Clues worksheet or refer to the workbook.
5. Explain that participants should work in pairs or small groups to identify and record the correct chemical parameters by following the clues on the handout or in their workbook. Read the posted chemical fact sheets to identify and record the correct chemical parameters on the handouts or in their workbooks.
6. Give 10 minutes to complete this activity and review the answers with the group.
7. Explain: “Three chemicals have been identified as priority for testing because they have the potential to cause serious health problems and occur over widespread areas.”

8. Ask: “Can you identify these priority chemicals from the activity you have completed?”
 - Arsenic, fluoride, nitrate
9. Ask: “A second priority for testing are chemicals, such as metals, that commonly cause water to be rejected for aesthetic (acceptability) purposes. What are they?”
 - Iron, manganese, and total dissolved solids (salinity)

Key Points

- It is not possible to test water for all chemicals that could cause health problems, nor is it necessary.
- Most chemicals occur rarely, and many result from human contamination of a small area, affecting only a few water sources.

15 minutes

Acceptability and Radiological Aspects



Use PowerPoint: Aspects of DWQ for this activity (optional).

1. Ask: “What factors affect the acceptability of drinking water?”
2. Hold a clear bottle of water and ask: “What characteristics of the water inside this bottle would make you question whether you would drink the water?”
 - Colour
 - Taste and smell
 - Temperature
 - Turbidity
3. Use PowerPoint or write down descriptions for each of the common acceptability aspects (optional).

Key Points

- For long-term behaviour change and use of HWTS, people must like the taste, smell, and appearance of their water.
- Some acceptability aspects (such as turbidity) may indicate microbiological contamination.

4. Use PowerPoint or describe radiological aspects, and explain why radiological aspects will not be covered in the training.
 - Radioactive substances from natural or human sources
 - Generally, the amount of radiation people consume in their water is very small compared to radiation exposure from other sources (e.g., the sun).
5. Use PowerPoint or present this statement on a flip chart: “For most water supply systems, which aspects of water quality are most important to monitor and treat?”
Give the participants some time to discuss their ideas.
 - Summarize key points below. Tell the participants that they will learn how to test for different contaminants throughout the workshop.

Key Points

- No single aspect of water quality is consistently considered the most important.
- Microbiological aspects are usually the most important for public health. They can have immediate and serious health consequences.
- Chemical aspects are sometimes very important (for example, in areas with high contamination). WHO maps show regions where chemical aspects are likely to be an issue. The health effects of chemical aspects in water take much longer to become apparent.
- Acceptability aspects may point to other issues and affect how people feel about drinking the water.
- Turbidity is an important parameter to consider when deciding which treatment options to use and when monitoring treatment.
- Radiological aspects people consume in their water is generally very small and not covered in this workshop.

10 minutes

Review

1. Write the following questions on individual pieces of paper: (or create your own)
 - What are the four aspects of drinking water quality?
 - Give two examples of chemical contaminants.
 - What are the four groups of pathogens?
 - What indicator bacteria is the international standard?
 - Give an example of a disease caused by waterborne bacteria.
 - Give an example of a helminth.
 - Which group of pathogens is the smallest?
 - Give some examples of acceptability aspects of drinking water quality.
2. Crumple the pieces of paper one at a time and place around each other to form a layered **paper cabbage**.
3. Ask the participants to stand in a circle and pass the paper cabbage around while you play music. When you stop the music, whoever has the cabbage should peel off a piece of paper, read the question, and give an answer.
4. Continue playing until all the questions have been answered.

10 minutes

Alternative review

1. Ask participants to complete the word search in their workbooks. They need to find:
 - Four types of pathogen
 - Four acceptability aspects
 - Three chemicals of concern

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Chemical Parameters Treasure Hunt

Handout

Chemical Parameter CLUES

Read the chemical parameter fact sheets posted on the wall of the classroom to help you identify the correct chemical associated with the clues below.

Clue #1

People in Village A refuse to drink the water from a newly drilled borehole. They say the water tastes bad and the water turns the laundry reddish brown.

Chemical = _____

Clue #2

The health clinic in a rural community has reported seeing people from a remote region with distinctive brown, pitted teeth and some have severe skeletal deformities.

Chemical = _____

Clue #3

An inspection of a newly drilled borehole shows signs of a white deposit surrounding the well apron. The users have complained of a salty taste and refuse to use the water.

Chemical = _____

Clue #4

People in Village B refuse to drink the water from a newly drilled borehole. The well apron has turned black and the users say the water tastes bad and turns their cooked rice black.

Chemical = _____

Clue #5

A large segment of the population collects water from wells. Many have developed hardened areas on their palms and feet. The incidence of cancer in the area is abnormally high.

Chemical = _____

Clue #6

In a rural agricultural community, several incidents of Blue Baby Syndrome have been reported.

Chemical = _____

Arsenic

Poster

Chemical Parameter Fact Sheet

Occurrence

- Naturally occurring in groundwater

Impacts/Health Effects

- Causes (long term exposure):
 - Light or dark spots on skin (chest, back or palms)
 - Hardening skin on palms and feet (keratosis)
 - Cancer
- Babies and young children are most vulnerable
- Biggest chemical issue in developing countries; high priority for WHO

WHO Guidelines

- WHO Guideline < 0.01 mg/L

National Guidelines

- Standards vary between countries

Treatment Options

- Options for arsenic contaminated water:
 - Choose a different water source
 - Treatment technology (e.g., Kanchan Arsenic Filter)

Fluoride

Poster

Chemical Parameter Fact Sheet

Occurrence

- Naturally occurring in groundwater and some surface water

Impacts/Health Effects

- Helps make teeth strong and prevents decay at **low** doses (0.5 – 1.0 mg/L)
- Higher doses can damage teeth by staining and pitting, dental fluorosis (1.5 – 4.0 mg/L)
- Very high doses harms the skeleton, causes changes to the bone structure and crippling effects, skeletal fluorosis (> 10 mg/L)

WHO Guidelines

- WHO Guideline < 1.5 mg/L

National Guidelines

- Standards vary between countries

Treatment Options

- Options for fluoride contaminated water:
 - Find an alternate source of water
 - Dilute with rainwater
 - Other techniques are still being researched and have not been implemented on a large scale, e.g., activated alumina, Nalgonda technique (alum/lime), bone charcoal, clay or contact precipitation, Nilogon filter (India)

Nitrate and Nitrite

Poster

Chemical Parameter Fact Sheet

Occurrence

- Naturally occurring in the environment as part of the nitrogen cycle

Uses/Characteristics

- Nitrate commonly used in fertilizer

Impacts/Health Effects

- Causes: High nitrate and nitrite may cause blue baby syndrome when baby formula is prepared with contaminated water (causes difficulty breathing and skin turns blue from lack of oxygen)
- Contamination from feces and from agricultural run off
- High nitrate levels are often associated with microbiological contamination since the nitrates may have come from fecal sources

WHO Guidelines

- Nitrate WHO Guideline < 50 mg/L
- Nitrite WHO Guideline <1.5 mg/L

National Guidelines

- Standards vary between countries

Treatment Options

- Options for nitrate contaminated water:
 - Find an alternate source of water
 - Dilute with rainwater

Chlorine

Poster

Chemical Parameter Fact Sheet

Occurrence

- Not usually found naturally in water in amounts that can cause harm

Uses/Characteristics

- Common disinfectant for drinking water
- Combined chlorine (reacted with organic matter to form new compounds)
- Consumed chlorine (kills pathogens in drinking water)
- Free chlorine (also called residual chlorine or free-residual chlorine) is what protects drinking water from recontamination

Impacts/Health Effects

- High amounts of chlorine can hurt skin, eyes, throat and lungs if touched or inhaled

WHO Guidelines

- WHO Guideline < 5.0 mg/L

National Guidelines

- Ideal level of free chlorine in drinking water: 0.2 – 0.5 mg/L

Treatment Options

- Options for chlorine in drinking water:
 - Adding chlorine is one option for water treatment; therefore, we normally do not try to remove it from drinking water.
 - Chlorine in drinking water helps keep it safe from pathogens.
 - If there is a strong smell and taste of chlorine, put the water in a closed container and shake the water vigorously or let the water sit overnight in a safe storage container. This will allow some of the chlorine to dissipate.

pH

Poster

Chemical Parameter Fact Sheet

Occurrence

- Depends on the water source, type of soil, rock, and chemicals present in the water

Uses/Characteristics

- pH between 6.5 - 8.5 is ideal for drinking water, more or less than those amounts indicates chemicals in the water

Impacts

- pH is one of the most important parameters for the effectiveness of many water treatment technologies. The optimal pH range for chlorine disinfection is between 5.5 and 7.5
- Acid rain has a pH < 5.6

WHO Guidelines

- No WHO Guideline for pH of drinking water

National Guidelines

- Standards vary between countries

Treatment Options

- The best way to deal with too high or too low pH is to use a different source of drinking water

Iron

Poster

Chemical Parameter Fact Sheet

Occurrence

- Naturally found in groundwater (boreholes) and some surface water

Uses/Characteristics

- Iron in **Groundwater** – might be dissolved, once exposed to air it turns the water reddish-brown
- Iron in **Surface water** – might be suspended, reddish-brown colour

Impacts/Health Effects

- No health impact
- Greater than 0.3 mg/L of iron:
 - Causes bad taste
 - Stains water pipes and well aprons
 - Stains clothes during washing

WHO Guidelines

- No WHO Guideline value

Treatment Options

- For suspended iron:
 - Strain water through a cloth
 - Let water sit in a container to settle
 - Filter (e.g., biosand filter)
- For dissolved iron:
 - Find a different source of drinking water
 - Dilute groundwater with a different source (e.g. rainwater)

Manganese

Poster

Chemical Parameter Fact Sheet

Occurrence

- Naturally found in groundwater (boreholes) and surface water
- From human activities in some areas (e.g., mining, industrial activities)

Uses/Characteristics

- Manganese in **Groundwater** – might be dissolved and not visible
- Manganese in **Surface water** – might be suspended, black colour or flakes
- Common to find manganese and iron together in water

Impacts/Health Effects

- No health impacts
- Greater than 0.15 mg/L of manganese:
 - Causes bad taste
 - Stains water pipes and creates a coating that comes off as small black flakes
 - Stains clothes during washing (blackish)
 - Stains food during cooking (blackish)

WHO Guidelines

- No WHO Guideline value (at levels causing acceptability problems in drinking water)

National Guidelines

- Standards vary between countries

Treatment Options

- Let water sit in a container and settle
- Strain water through a cloth or filter (e.g., biosand filter)
- Find a different source of drinking water or dilute with a different source (e.g. rainwater)

Total Dissolved Solids

Poster

Chemical Parameter Fact Sheet

Occurrence

- Natural sources, and to a lesser extent from runoff, sewage, and industrial wastewater

Uses/Characteristics

- Mainly inorganic salts that are dissolved in water: calcium, magnesium, potassium, sodium
- Might include small amounts of organic matter
- Testing total dissolved solids (TDS) does not give specific information about chemicals in water
- More specific testing is needed to find out which chemicals are present

Impacts/Health Effects

- No direct health impacts
- High amounts (>1,200 mg/L) may affect the taste of water (bitter or salty taste)

WHO Guidelines

- No WHO Guideline value

National Guidelines

- Standards vary between countries

Treatment Options

- Dilute with a different water source (e.g. rainwater)
- Reverse osmosis filtration