SEHGAL FOUNDATION

FLUORIDE AND FLUOROSIS MITIGATION

Note to Readers

This manual is a work in progress, and we recognize that the learning never stops especially when it comes to addressing complex challenges like fluoride and fluorosis. We actively welcome your suggestions and feedback to strengthen this resource and make it more effective in building capacities for fluoride mitigation at the grassroots level.

If you have inputs, experiences to share, or would like to know more, please feel free to reach out to:

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Together, let's continue to improve and co-create knowledge that empowers communities toward safe water and better health.

ACKNOWLEDGEMENT

The development of this Fluoride and Fluorosis Mitigation Manual has been a long collaborative and learning-rich journey, and it would not have been possible without the valuable support, guidance, and encouragement of several individuals and organizations.

We are also sincerely grateful to late Prof. (Dr.) A.K.Susheela, Executive Director, Fluorosis Foundation of India and the INREM Foundation for their valuable knowledge and longstanding contribution in the field of fluoride and fluorosis. Their constructive feedback during the pilot phase of this manual was instrumental in refining its content and approach.
We are also deeply thankful to Mr. Nanakkumar T Santdasani, UNICEF (Rajasthan), Dr. Kunal Kanti Majumdar, KPC Medical College & Hospital, Jadavpur, and many individual, trainers, field practitioners, researchers, community facilitators, and colleagues who reviewed the content, offered critical feedback, and shared real-world insights to ensure that the manual remains relevant, accessible, and action-oriented. Your contributions have helped us refine and finalize the lesson plans, making them not just informative but also truly usable by those working in the field.

We extend our heartfelt gratitude to CAWST (Centre for Affordable Water and Sanitation Technology), Canada, for their unwavering support in shaping this manual. Their expertise and structured approach to lesson plan played a crucial role in giving this resource a cohesive and practical form. The spirit of partnership and knowledge exchange with CAWST has enriched this initiative immensely.

We are deeply grateful to Dr. Suri Sehgal (Founder and Chairperson Emeritus), Mr. Jay Sehgal (Chairperson of the Board of Trustees), and Ms. Anjali Makhija (Trustee and CEO, S M Sehgal Foundation) for their encouragement and visionary leadership in advancing sustainable solutions for Fluoride and Fluorosis mitigation, promoting safe water access through community-centered initiatives and building the capacities of grassroots practitioners.

Most importantly, we acknowledge the resilience and voices of the communities we work with. It is for them and with them that this manual has been created. We hope it serves as a meaningful tool in their ongoing efforts to access safe water and lead healthier lives.
To all who contributed to this endeavor, directly or indirectly thank you for being part of this journey.

S M Sehgal Foundation

FOREWORD

Access to safe drinking water is a fundamental human right and a foundation of public health. Yet, for millions across the world, this basic necessity is compromised by the invisible threat of fluoride contamination. What makes fluoride particularly challenging is that it often goes unnoticed because of no change in its taste, color and odor until its effects manifest in the form of dental, skeletal, or non-skeletal fluorosis. These effects can be painful, disabling, and, in many cases irreversible.

At S M Sehgal Foundation, we have witnessed firsthand the toll that excessive fluoride in drinking water takes on rural communities. For those who rely on groundwater sources without access to regular testing or treatment options, the risks are especially severe. Women, children, and marginalized groups are disproportionately affected, both in terms of health outcomes and the burden of care within households.

Despite growing concern and decades of scattered interventions, there remains a critical lack of structured, practical learning tools that can help communities, educators, and practitioners understand the issue in depth and take informed action. This manual is our humble attempt to address that gap.

Designed to be participatory and action-driven, the manual brings together scientific knowledge, practical solutions, and community engagement strategies to support fluoride and fluorosis mitigation efforts at the grassroots level in easy to understand de-mystified manner. From understanding sources and symptoms to reducing ingestion and developing action plans, the manual serves as a comprehensive guide for creating healthier, more resilient communities.

We are proud of the collaborative effort that has gone into the development of this resource. It reflects our belief in local leadership, informed decision-making, and the power of knowledge to transform lives. We hope it will serve as a catalyst for dialogue, awareness, and most importantly, action.

Let us continue to work together to ensure that every individual, regardless of where they live, has the right to safe drinking water to lead a healthy life.

Anjali Makhija
Trustee and Chief Executive Officer
S M Sehgal Foundation

Lalit Mohan Sharma
Principal Scientist
S M Sehgal Foundation

PREFACE

Fluoride, a naturally occurring mineral, plays a complex role in human health. In optimal amounts, it contributes to dental health and skeletal development; however, prolonged exposure to high concentrations especially through drinking water can lead to serious health concerns. Globally, millions are at risk of fluorosis, a crippling condition caused by excessive fluoride intake, which affects the teeth, bones, and even non-skeletal systems causing impacts of malnutrition.

Fluoride contamination in groundwater is a pressing public health issue, with over 20 Indian states reporting fluoride levels in drinking water that exceed the permissible limits set by Bureau of Indian Standards (BIS). Rural communities are particularly vulnerable due to their dependence on groundwater sources. Despite the seriousness of the problem, awareness about fluoride contamination and fluorosis remains limited. Interventions are often isolated and fragmented, and there is an absence of structured, context-specific educational materials for communities, educators, and field practitioners.

This manual is a pioneering step to address that gap. It is among the first comprehensive educational resources focused on fluoride and fluorosis mitigation through participatory and action-oriented learning. Covering a range of essential topics; including water contamination with a focus on fluoride, identifying contaminated sources, understanding prevalence and benchmarking, fluoride ingestion through various pathways, and the classification and symptoms of dental, skeletal, and non-skeletal fluorosis, this manual provides a clear and practical learning journey.

In addition, the manual offers guidance on prioritizing health concerns, conducting fluoride water testing, reducing fluoride ingestion through household water treatment, managing early symptoms of fluorosis, and fostering sensitization and awareness at both household and community levels. Above all, it enables participants to develop localized action plans that are both practical and impactful.

We hope this manual empowers facilitators, field workers, educators, and community leaders to initiate informed discussions, build collective understanding, and inspire tangible actions to reduce fluoride exposure and fluorosis management. This is more than a learning resource it is a commitment to ensuring safe drinking water and promoting fluoride free futures for all.

Water, Research and Training Team:
Lalit Mohan Sharma, Yashi Gautam and Aparajeeta
S M Sehgal Foundation, India

TABLE OF CONTENTS

65 minutes total

Lesson Plan

Safe Water

Lesson Purpose

To help participants understand water sources, contaminants, and the connection to safe water.

Learning Outcomes

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

1. Define safe drinking water
2. Map water sources and list ways the water is used
3. Identify common sources of water contamination
4. Classify contamination into one of three categories

Materials

- Four glass bottles
- Tea bag
- Flour or whiteboard chalk
- White vinegar
- Clear water
- Handout of the water cycle
- Workbooks
- Marker pens
- Post-its
- Whiteboard/flipchart
- PowerPoint
- Projector

Preparation

- Write learning outcomes on flipchart paper
- Prepare four bottles of water, each deliberately contaminated as follows:
    - Bottle 1: Water with tea bag (to mimic discoloration)
    - Bottle 2: Water mixed with white chalk or flour (to create cloudiness)
    - Bottle 3: White vinegar (to mimic smell of an unknown contamination)
    - Bottle 4: Clean, safe drinking water (control sample)
- Write the definition of safe drinking water on flipchart paper
- Print water cycle image
- Prepare PowerPoint with:
    - The definition of safe drinking water
    - The three categories of contamination
    - Common sources of contamination

5 minutes

Introduction

Objective: Analyze and differentiate between various water samples to determine which is safe for drinking.

1. Place the four pre-prepared bottles of liquid on display in front of the participants. Do not allow them to touch the bottles.
2. Ask participants:
    - "Which of these bottles would you drink from? Why?"
        i. They may say it looks cleaner, no colour, not contaminated
    - "Why would you not drink the dirty water?"
        i. "I might get sick"
3. Pass the four bottles around the group. Let participants open each bottle and smell the contents.
4. Ask, "Have you changed your choice of which liquid you would drink? Why?"
    - Most will say "yes" because the clear liquid smells bad.
5. Ask, "Is the clear water safe to drink? Why or why not?"
    - Possible answers: there could be contaminants you cannot see, like chemicals or pathogens
6. Ask, "Why are we all here?"
    - We don't want community members to get sick.
7. Summarize:
    - We are all here because we care that our communities can access safe water and live healthy lives.
    - Some contaminants do not change the appearance of water but may harm health.
    - Water that appears turbid or colored is immediately rejected, but even clear water may contain some objectionable contaminants that may cause serious health risks.

Trainer's note:

Water with a lot of turbidity or color tends to be more contaminated than water that is clear, but just because water is clear doesn't mean it is free of pathogens or other impurities

Many chemicals are odorless and colorless/ many toxic liquids are clear.

10 minutes

Safe Water

Objective: Define safe drinking water.

1. Ask the whole group, "What are the characteristics of safe water?"
2. Record responses on flipchart paper.
    - Responses should include clear, pathogen-free, low in concentrations of toxic chemicals, tasteless, odourless, colourless
3. Ask participants to work in pairs to come up with a simple definition of safe drinking water and write it in their notebook.
4. Display the WHO definition for safe drinking water on PowerPoint (slide 1). Ask participants to write the definition in their workbooks.
    - *Safe drinking water does not represent any significant risk to health over the lifetime of consumption, including different sensitivities that may occur between life stages. (WHO, 2023)*
5. Ask participants how their definitions differed from the WHO definition. Ask what the WHO definition means. Responses could include:
    - Safe drinking water will not make people sick at any time throughout their life, including when they are young, old, or sick.
    - Safe drinking water should be good to use for all our personal needs, including drinking, cooking, and washing.
6. Present the learning outcomes or an overview of the lesson.

15 minutes

Water Mapping

Objective: Analyze and reflect on personal water sources and explain the processes of the water cycle

1. Facilitate a discussion to map the water's journey from the source to their home. Introducing the water cycle. Ask them to do the following:
    - "Draw your town." [give example]
    - "Draw where the water comes from." [e.g., wells, pods, rainwater) [hint: think about the water cycle]
    - "State the different ways water is used. Are the sources different for different uses?"
    - "Where might impurities come from?" [e.g., latrines, HH grey water, livestock, agriculture, trash, geology]
7. Ask: "What is the water source at your home? Where does it come from? How does it traverse back?"
8. Encourage participants to think about and share which portion of their water journey is vulnerable to contamination.

Trainer Tips

Guide the discussion on the journey of water from its source to their homes, and how it eventually connects to the water cycle.

Emphasize key concepts such as evaporation, condensation, transpiration, precipitation, storage, infiltration, rivers, and oceans. Ensure participants understand the complete water cycle.

Discuss the forward and backward journey of water from their source to the point of use. Focus on the possible contamination points in the water cycle as well as source to the point of use (POU) and further storage and handling at point of use.

25 minutes

Water Contamination

Objective: Categorize types of water contamination and define common sources of contamination .

Use participant drawings from the previous section.

1. Ask participants to review the drawings and list the impurities on post-its (1 impurity/post-it).
2. Have participants add their post-its to the whiteboard.
3. Introduce the three categories of contamination on the PowerPoint presentation (slide 2):
   - **Physical Contamination** – A change in the physical properties of water, such as its color, taste, turbidity, temperature, suspended solids, and odor. This is also known as the acceptability parameter.
   - **Chemical Contamination** – Involves harmful substances that make it unsafe for use, posing significant health risks. Vulnerable populations face exposure through drinking, cooking, and irrigation, with prolonged exposure increasing the risk of toxicity, illness, and environmental harm.
   - **Biological Contamination** – Occurs when water is contaminated by pathogens like viruses, bacteria, protozoa, and helminths. Consuming water contaminated with these microorganisms can lead to illnesses such as diarrhea, cholera, typhoid, and dysentery, which can be severe or even fatal, especially in vulnerable populations like children and the elderly.
4. Ask the participants to sort post-its into the three categories.
5. Ask participants to brainstorm more examples for each category. Add them to the whiteboard.
6. Ask participants to look at their drawings and identify sources of contamination. Brainstorm the list together and ask participants how these sources could be categorized.
7. Review and display the definitions of **common sources of contamination** on PowerPoint (slide 3):
   - **Geogenic** – Refers to the presence of naturally occurring originating from the Earth's geological formations and entering water supplies through natural processes. Common

geogenic contaminants include arsenic, fluoride, and iron. These elements can leach into groundwater from rocks and soils over time. Although these contaminants are naturally occurring, they can pose serious health risks in high concentrations.

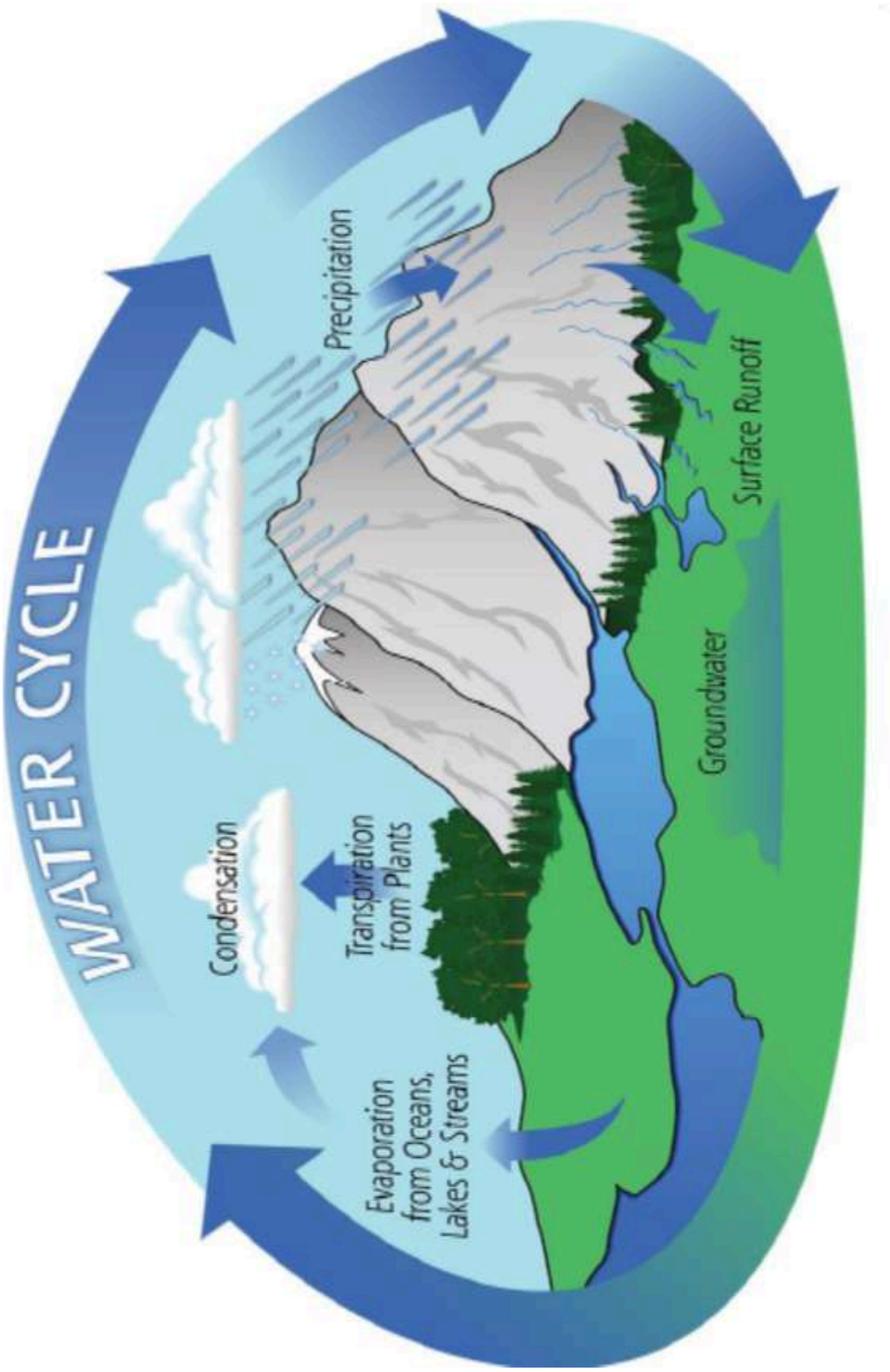
- **Industrial discharge** – Discharge from factories and industrial plants often releases waste products into nearby water bodies. This discharge can include harmful chemicals, heavy metals, and other pollutants. These contaminants can poison water supplies, harm aquatic life, and pose serious health risks to humans.
- **Agricultural practices** – Involves the chemicals used in agriculture (fertilizers, pesticides, and herbicides) which can run off into water sources during rainfall or irrigation. These chemicals can contaminate drinking water, leading to health issues such as chemical toxicity and disrupting ecosystems.
- **Poor Sanitation -** Inadequate sanitation infrastructure and facilities can lead to the improper disposal of human waste, which can seep into water sources. This can introduce harmful bacteria, viruses, and parasites into the water, causing widespread waterborne diseases like cholera and diarrhea.

10 minutes

Review

1. Bring up the definition of safe water.
2. Pair share: Ask participants to discuss the following:
    - "In communities where you work, what are the types of contaminants that impact health?"
    - "Are there contaminants that pose a greater risk over a lifetime of exposure?"
    - "Are there contaminants that pose a greater risk in the short term?
    - Who are community members who are most vulnerable? Why? (HINT: Think of different sensitivities that may occur between life stages)

Resources:


WATER CYCLE
Precipitation
Surface Runoff
Groundwater
Transpiration from Plants
Condensation
Evaporation from Oceans, Lakes & Streams

PowerPoint

Slide 1: Safe Drinking Water: Definition

“Safe drinking water does not represent any significant risk to health over the lifetime of consumption, including different sensitivities that may occur between life stages.” (WHO, 2023)

Slide 2: Three categories of contamination:

- **Physical Contamination:** A change in the physical properties (also known as the acceptability parameter) of water, such as its color, taste, turbidity, temperature, suspended solids, and odor.
- **Chemical Contamination:** Involves harmful substances that make it unsafe for use, posing significant health risks. Vulnerable populations face exposure through drinking, cooking, and irrigation, with prolonged exposure increasing the risk of toxicity, illness, and environmental harm.
- **Biological Contamination:** This occurs when water is contaminated by pathogens like viruses, bacteria, protozoa, and helminths. Consuming water contaminated with these microorganisms can lead to illnesses such as diarrhea, cholera, typhoid, and dysentery, which can be severe or even fatal, especially in vulnerable populations like children and the elderly.

Slide 3: Common sources of contamination:

- **Geogenic:** Geogenic contamination refers to the presence of naturally occurring originating from the Earth's geological formations and entering water supplies through natural processes. Common geogenic contaminants include arsenic, fluoride, and iron. These elements can leach into groundwater from rocks and soils over time. Although these contaminants are naturally occurring, they can pose serious health risks in high concentrations.
- **Industrial Discharge:** Discharge from factories and industrial plants often releases waste products into nearby water bodies. This discharge can include harmful chemicals, heavy metals, and other pollutants. These contaminants can poison water supplies, harm aquatic life, and pose serious health risks to humans.
- **Agricultural Practices:** This involves the chemicals used in agriculture (fertilizers, pesticides, and herbicides) which can run off into water sources during rainfall or irrigation. These chemicals can contaminate drinking water, leading to health issues such as chemical toxicity and disrupting ecosystems.
- **Poor Sanitation:** Inadequate sanitation infrastructure and facilities can lead to the improper disposal of human waste, which can seep into water sources. This can introduce harmful bacteria, viruses, and parasites into the water, causing widespread waterborne diseases like cholera and diarrhea.

90 minutes total

Lesson Plan

Fluoride: Source, Prevalence & Benchmarking

Lesson Purpose

To educate participants about sources of fluoride in water, geographical prevalence, and benchmarking.

Learning Outcomes

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

1. Understand different sources of fluoride in water.
2. Identify the different geographical areas that have fluoride in water
3. Understand fluoride levels in drinking water: standards and guidelines

Materials

- Whiteboard/flipchart
- Sticky notes
- Fluoride presence map of India printout
- Map of India
- Three glasses of water
- Salt
- Pink rock salt
- Food colouring
- Rock samples (weathered and intact)
- Traffic light color cards
- Whistle
- WHO and BIS standard handout

Preparation

- Write learning outcomes on flipchart paper.
- Prepare three separate glasses of water:
    i. Glass 1: Water with No salt
    ii. Glass 2: Water with a pinch of salt
    iii. Glass 3: Water with a teaspoon of salt
- Prepare two separate glasses of clear water
- Print image
    i. Map of India
- Prepare PowerPoint with:
    i. Pictures of weathered or non-weathered rock samples
    ii. Image of other sources of fluoride contamination
    iii. Definition of the term concentration with its units
    iv. Fluoride benchmarking through traffic lights
    v. Table of WHO and BIS fluoride standards

5 minutes

Introduction

Objective: Demonstrate the concept of concentration using a simple taste test and relate it to fluoride levels in water.

1. Place three glasses of salt water in mixed order at the front of the room.
2. Ask three volunteers to taste their water at the same time. Assure them that it is safe to taste. But just taste, don't take a big gulp.
3. Ask participants and volunteers to observe the reaction of other volunteers while tasting the water.
4. Ask the volunteers to determine the difference between their glasses
5. Ask volunteers to put the glasses in order (based on the reaction of volunteers).

20 minutes

Source of Fluoride in Water

Objective: Discuss about the presence of fluoride in water and explain the concept of chemical contamination.

1. Brainstorm in a large group the following topics:
    1. *In some places, water tastes saltier than others. What might be the source of the saltiness?*

       Possible answers might include water from boreholes, water near the coast, water from brackish surface sources, industrial effluent pollution.
    2. Continue with probing questions if a geological source is not mentioned

       "What could be causing the saltiness in some waters that are not directly near the coast?"
2. Introduce the concept of geological source:
    - Show **pink rock salt** to the group and ask, "what is this rock and where does it come from? Is it water soluble?"
    - "Does it make any physical change in the water (taste, smell, color, turbidity)?"
3. Introduce the concept of fluoride contamination in water:
    - Fluoride, like salt, can be found naturally in the Earth's crust and is water soluble. When rocks containing fluoride minerals weather or break down, some part of fluoride dissolves into the water.
    - Use the analogy: Just like salt dissolves in water, fluoride also dissolves from certain minerals in the Earth's crust into water sources, such as groundwater or surface water.

Optional Activity: Pass around some weathered rock samples or show the pics of weathered rocks and non-weathered rocks on PowerPoint (slide 1)

4. Pass around weathered rocks or pictures that contain **fluoride minerals** (**apatite**, **fluorite** and **biotite**) (if not samples, then show pictures).
5. Ask: What do you think happens when these rocks weather? How do the minerals in these rocks get into water?"
    - Weathering of rocks releases fluoride (and other minerals) into the groundwater, which may lead to fluoride contamination in the water source.
    - Optional – pass around some rock samples that have fluoride minerals.

Trainer Note:

Explain to participants that fluoride is a ubiquitous element that is pervasive and prevalent. It is released through the weathering of fluoride-rich rocks like granite, apatite, and fluorite, and dissolves easily in water without changing its color, taste, or smell, making it impossible to detect without testing.

In rocky areas, especially where water movement is slow, such as in deep aquifers, fluoride can accumulate in high concentrations in water sources. Additionally, industrial waste, the use of certain fertilizers, insecticides, and pesticides can also contribute to fluoride presence in water.

10 minutes

Sources of Fluoride Contamination

Objective: Explain fluoride contamination in groundwater and surface water.

1. Highlight different sources of fluoride contamination in water, including:
    - **Groundwater sources:** Fluoride is often present in groundwater when it travels through fluoride-containing rocks or aquifers (e.g., granite, fluorite, apatite). As the groundwater moves through these rocks, it dissolves fluoride and carries it to wells or other water sources.
    - **Rivers or runoff:** Similarly, rivers and surface runoff can carry fluoride, especially in areas where the water flows through weathered mountain ranges or rocks with high fluoride content. Sediments deposited by rivers and runoff may also contain fluoride, affecting water quality. Often the concentration of fluoride in surface water is low due to run-off being huge and low time of contact.
    - **Aquifer recharge and contamination:** When water recharges an aquifer, it may carry fluoride from weathered rock formations, leading to contamination of groundwater.
2. Divide participants into small groups (3-4 people) and distribute the printed copy (or show on PowerPoint slide 2) of the image showing the different sources of fluoride contamination.
3. Explain to the participants how the different sources are causing fluoride contamination.

Trainer Note:

Relate the discussion from the common sources of contamination mentioned in Lesson Plan 1 (Safe Water)

10 minutes

Geographic Presence of Fluoride in India

Objective: Explore the geographic presence of fluoride.

1. Divide the participants into small groups and distribute the map of India with a marker.
2. Ask participants to circle states/ areas on the map where they believe fluoride levels in water might be high or low, based on their knowledge or experience with a reason.
3. Present a map showing the fluoride concentration across India. Allow participants to observe and compare with their own map.
4. In the larger group, discuss the regions that surprised them and the reason.

Trainer Note:

Remind participants that older rocks, due to prolonged weathering, are more likely to release higher concentrations of fluoride into water compared to newer rocks.

For example, Himalayan rock is new rock, areas (Jammu & Kashmir, Uttarakhand and Himachal Pradesh) covered by these ranges generally have no to low fluoride concentration. Aravalli rocks are the oldest rocks found in the regions of Rajasthan, Haryana and Gujarat. These regions have medium to high concentration of fluoride in groundwater.

10 minutes

Concentration of Fluoride

Objective: Explain the concept of concentration and units through visual demonstration.

1. Take two glasses, having one full with water and another with half full with water. Add food color drop by drop to each glass. Highlight how the color becomes more intense with each added drop, showing a clear visual change from light to dark shade. This demonstrates increasing concentration.
    - Relate to the 3 glasses in the introduction where being colorless, varied salt concentration was observed through taste.
    - Highlight that even if fluoride in water is invisible (color, taste, or smell), its concentration may vary.
    - Adding the same quantity of color makes different shades of color of water because of the different quantity of water contained in glass.

2. Explain the term concentration. "*The amount of a component per unit volume of a mixture*". Use the changing color in the glasses to illustrate how concentration increases with more coloring.
3. Explain that measurement without units is meaningless. Units are standards that define the scale of measurement
4. Introduce the units of fluoride concentration on a PowerPoint slide (slide 3):
    - Parts Per Million (PPM) or mg/L
    - Parts Per Billion (PPB) or µg/L.
5. Explain the conversion
    - 1 PPM = 1000 PPB
    - 1 mg/L = 1000 µg/L
6. Clarify that the intensity of the color is like fluoride levels in water, more fluoride means a higher concentration, which can be quantified using PPM and PPB.

25 minutes

Fluoride Benchmarking

Objective: Explain the importance of the fluoride concentration benchmark set by WHO and BIS through an engaging participatory activity.

1. Ask the volunteer from the group to play the role of "Traffic Inspector" (provide a whistle and Paper hat to the inspector). The rest of the participants will pretend to be the driver in the training area.
2. Explain the traffic light signals to everyone (slide 4):
    - Red means **STOP**
    - Yellow means **SLOW DOWN**
    - Green means **GO**
3. The driver must obey the signals or the traffic inspector will issue a fine.
4. Ask a few participants to break the traffic signals intentionally and encourage participants to observe the fine imposed.
    - Can display traffic lights, one by one to make sure that the when red light is there, participants will stop and if anyone moves, then fine. Then display green light and yellow.
5. Debrief the participants about the traffic signal activity and relate it to the fluoride concentration levels. Connect back with the definition of safe water.
    - *Green represents the **"ACCEPTABLE / DESIRABLE LIMIT" < 1mg / L***
        i. *Low risk of negative health impact*
    - *Yellow represents the **"PERMISSIBLE LIMIT" 1mg / L - 1.5 mg / L***
        i. *Some risk to vulnerable people with long exposure period*
    - *Red represents **"DANGER - MORE THAN THE PERMISSIBLE LIMIT" > 1.5 mg / L***
        i. *High risk of health impacts with long exposure period*

6. Explain that crossing the **Red light (permissible limit)** results in a fine, just like how exceeding fluoride limits in water can lead to health risks.
7. Emphasize that traffic fines are paid in cash but exceeding fluoride limits is the health risk posed by fluoride present in water.
8. Distribute handouts of WHO and BIS standards (slide 5) in drinking water and explain their significance:
    - WHO guidelines recommend actions at >0.5 mg/L to prevent risks.
    - BIS standards define 1.0 mg/L as acceptable or desirable limit and 1.5 mg/L as permissible limit for fluoride.
9. Explain the difference between guidelines and standards:
    - **Guidelines:** Recommendations for safe practices.
    - **Standards**: Mandatory requirements

10 minutes

Review

1. Ask participants to revisit the prevalence map using WHO & BIS standard handout as a guide and identify which region in India is in “green", “yellow” and “red” zone.

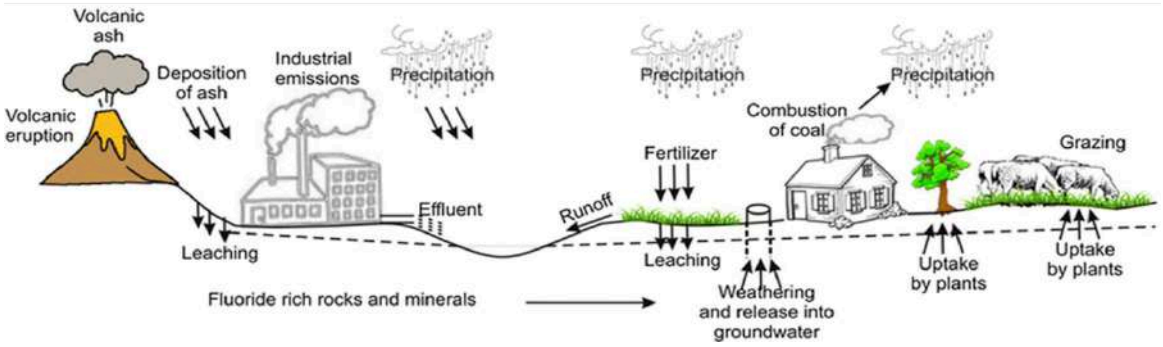
Resources:

Picture: Pink Rock Salt

Optional Activity Slide 1: Rocks in Different Stages of Weathering

Slide 2: Other sources of fluoride contamination

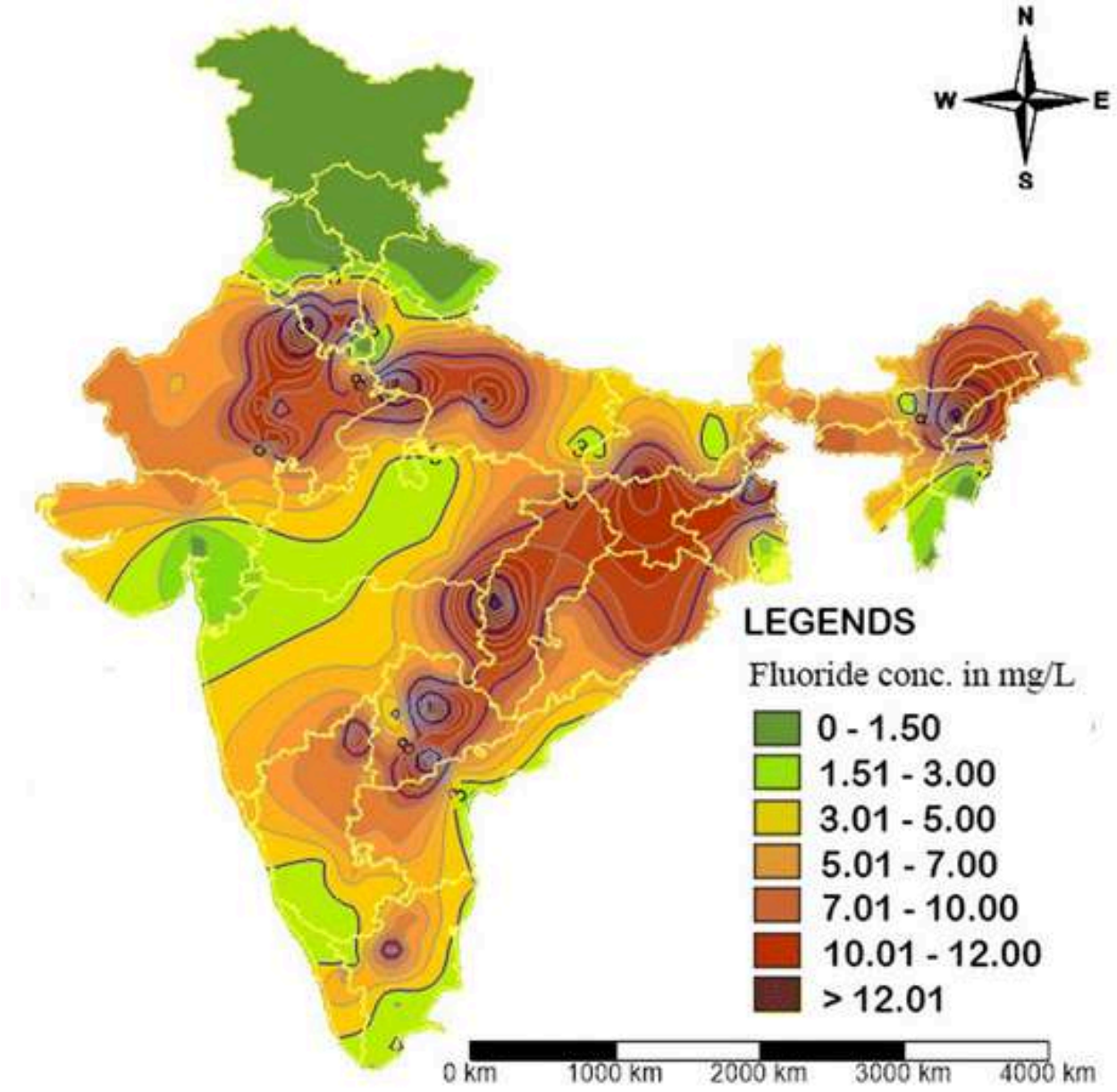
Fluoride contaminations in air, water and land are derived through assorted causes viz; granite rocks dissolution, percolations during rains and manmade activites.



Map of India


Jammu & Kashmir
Srinagar / Jammu
Ladakh
Leh
Himachal Pradesh
Shimla
Chandigarh
Chandigarh
Punjab
Chandigarh
Uttarakhand
Dehradun
Harayana
Chandigarh
New Delhi
Rajasthan
Jaipur
Uttar Pradesh
Lucknow
Bihar
Patna
Sikkim
Gangtok
Arunachal Pradesh
Itanagar
Assam
Dispur
Nagaland
Kohima
Manipur
Imphal
Tripura
Agartala
Mizoram
Aizawl
Meghalaya
Shillong
Jharkhand
Ranchi
West Bengal
Kolkata
Gujarat
Gandhinagar
Madhya Pradesh
Bhopal
Chhatisgarh
Raipur
Orrisa
Bhubaneshwar
Dadra and Nagar Haveli and Daman & Diu
Daman
Maharastra
Mumbai
Telangana
Hydrabad
Goa
Panji
Andhra Pradesh
Hydrabad
Andaman & Nicobar Islands
Port Blair
Karnataka
Begaluru
Lakshadweep
Kavaratti
TamilNadu
Chennai
Kerala
Thiruvananthapuram
Puducherry
Puducherry
States
Union Territories

Fluoride Concentration Levels



Slide 3: Units and Concentration

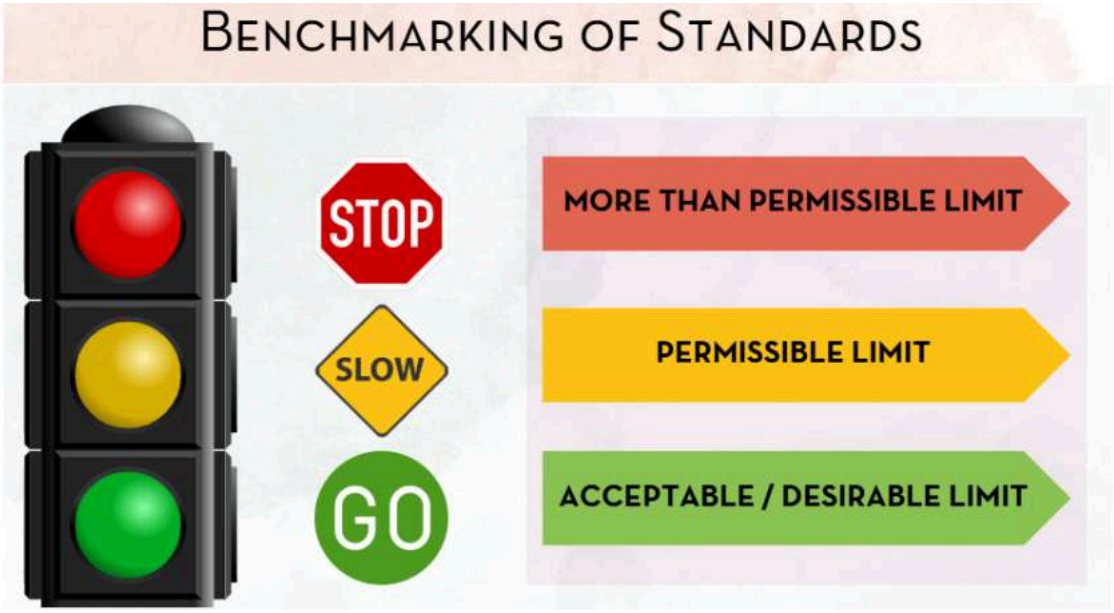
Concentration

"The amount of a component per volume of a mixture".

1 PPM = 1000 PPB

1 mg/L = 1000 µg/L

Slide 4:



Slide 5: WHO and BIS Standard handout

BENCHMARK: FLUORIDE IN WATER

Standards	Acceptable Limit (PPM)	Permissible Limit (PPM)
Bureau of India Standards (BIS)	1	1.5
World Health Organization (WHO)	0.5	1.5

70 minutes total

Lesson Plan

Fluoride: Ingestion Through Different Sources

Lesson Purpose

To educate participants about the ingestion of fluoride from different sources and their adequacy and tolerability.

Learning Outcomes

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

1. Recognize different sources of fluoride in our consumption.
2. Consider diagnosing fluorosis when symptoms are present, even in areas with acceptable levels of fluoride in drinking water.
3. Calculate and assess the total fluoride ingested and compare it with adequate and tolerable levels.

Materials

- Whiteboard/flipchart
- Sticky notes
- Pictures of items that contain fluoride
- Toothpaste picture card
- Cosmetic printout
- Amount of fluoride and food (handout)
- Adequate and upper tolerable Limit (handout)
- Collection of items that contain fluoride, such as:
  - Foundation
  - Mascara
  - Coffee beans
  - Cigarette
  - Toothpaste
  - Chewing gum
  - Medicine
  - Betel nut
  - Black salt
  - Lipstick
  - Mouthwash
  - Rice
  - Tea

Preparation

- Write learning outcomes on flipchart paper
- Print/prepare picture cards for fluoride, toothpaste, cosmetics, etc.
- Prepare PowerPoint with:
  i. Armar story
  ii. Dental products
  iii. Cosmetic products
  iv. Ram story

5 minutes

Introduction

1. Show the pics of items that contain fluoride to participants one by one.
2. Ask participants to sort items into two groups:
    a) Things that contain fluoride
    b) Things that do not
3. Explain that (surprise!) they all do. Point out items that have the most fluoride.

10 minutes

Fluoride Ingestion from Various Sources

Objective: Explore the concept of fluoride ingestion from various sources

1. Split into small groups, read **Armar Story** (found in *Resources* section and Slide 1) in your group
2. Identify potential causes of the mysterious illness in Tibet.
3. Ask participants to guess the source of Armar's affliction.

HINT: Explain that Tibet is a Buddhist country. Devotee Buddhists spend long hours chanting sutras and drinking tea.

4. Introduce the definition of fluorosis: ***The stress or strain caused by the fluoride reaction with calcium and magnesium present in the body part*.**
5. Explain the following:
    - The rampant fluorosis among the Tibetan people is caused by consuming traditional Tibetan brick tea, also known as "churned tea" or "butter tea."
    - Traditional Tibetan brick tea uses lower quality leaves and stems, which absorb higher amounts of fluoride from the soil.
    - The preparation method (boiling and mixing with yak butter and salt) releases and adds fluoride into the tea.
    - Average consumption of 40-50 cups of tea daily results in high fluoride intake, affecting both adults and children, especially when mixed with staple foods like tsampa.
6. **Additional Information (Optional):** Explain that there have been other cases of fluorosis in individuals who were not consuming water with high fluoride concentrations, including one case where osteofluorosis was reported in France due to excessive use of fluoride-containing toothpaste. (SpringerLink).

10 minutes

Fluoride Ingestion

Objective: Recognize that fluoride exposure comes from different sources.

1. Handout the flipchart paper to each group with titles: **Dietary sources, Dental products, Medication & supplements, and Industrial exposure.**
2. Ask each group to brainstorm the potential ways of fluoride can be ingestion based within these categories
3. Use the table below for discussion.

Dietary sources	• **Food grown in fluoride-rich soil**: In areas where soil contains high levels of fluoride, crops like tea, leafy vegetables, and certain grains can accumulate fluoride. • **Tea consumption**: Tea plants naturally absorb fluoride from the soil. High tea consumption has been associated with skeletal fluorosis, particularly in areas where water fluoride levels are low but tea consumption is high. • **Processed foods**: Some processed foods and beverages may be made with fluoridated water, leading to increased intake of fluoride
Dental products	• **Toothpaste ingestion:** Young children, in particular, may develop dental fluorosis from swallowing fluoride toothpaste during toothbrushing, especially if the fluoride content in the toothpaste is high. • **Did you know?** In some parts of the world fluoride is added into the drinking water to prevent tooth decay!
Medications and supplements	• **Fluoride supplements:** Overuse of fluoride supplements or medications containing fluoride can cause fluorosis. • **Fluoride-containing medications:** Some medications, like certain anesthetics or drugs containing fluoride compounds, have been linked to cases of fluorosis when used inappropriately or over long periods.
Industrial exposure	• **Occupational exposure:** Workers in certain industries, such as aluminum production, ceramics, and phosphate fertilizer plants, may be exposed to high levels of fluoride via inhalation or skin contact, leading to fluorosis. • **Air pollution:** In areas near industries that release fluoride-containing emissions, people may be exposed to fluoride through air or contaminated soil and water.

4. Hand out the picture cards of toothpaste and other dental products (slide 2). Discuss how these everyday products contribute to fluoride intake.
5. Provide cosmetic printouts to the participants and ask if they consider the make-up products as a potential source of indirect fluoride ingestion.

Trainer's Note:

Fluorosis, caused by excessive fluoride exposure, could theoretically result from "long-lasting", "waterproof" and "water resistant" cosmetic products through three routes:

Tear Duct Absorption: Cosmetics like mascara or eyeliner containing fluoride might come into contact with the eyes. Fluoride could be absorbed via tear ducts into the body over time, although this is a rare possibility.

Inhalation: Aerosolized products like hair sprays or setting sprays containing fluoride could be inhaled. Long-term exposure might lead to fluoride accumulation in the lungs, which could contribute to fluorosis.

Ingestion: Products applied near the mouth (e.g., lipstick) could be ingested accidentally through eating. Over time, this small but continuous ingestion could contribute to fluoride buildup.

Ingestion sources of fluoride because of per and polyfluoroalkyl substance (PFAs) which are anthropogenic substances (Whitehead et al., 2021).

35 minutes

Assessing Total Fluoride Intake

Objective: Learn how to assess when total fluoride intake from all sources is at high risk levels.

1. Read and display on PowerPoint (slide 4) the following story to participants:

Ram, a diabetic, drinks unsweetened tea and avoids sweets and desserts, but his blood sugar remains high. His doctor asks about his diet, and Ram explains that he enjoys poha, parathas, samosas, and fresh fruit juice, thinking they are safe.

The doctor explains that even though these foods don't taste sweet, they contain hidden sugars or carbohydrates that can spike blood sugar. The doctor also points out that the sweet tamarind chutneys Ram loves with his meals are full of sugar. Surprised, Ram realizes that even salty and natural foods can hide sugars.

The doctor explained that consuming sugar in any form adds to the overall blood sugar levels, and it's crucial to monitor sugar intake from all sources.

2. Ask the participants how the story might relate to fluoride intake from various sources.

3. Engage the participants by providing them with details of the amount of fluoride present in food (handout/PowerPoint slide 5), adequate fluoride intake (slide 6) and upper tolerable limit (slide 7) handouts from all sources (attached in annexure).
4. Referring to the handouts, ask participants to calculate the potential fluoride intake for given case studies. These will be completed progressively, one-by-one (solutions given in annexure).

Case Study 1:

Ram is drinking water 3 lit/day, that water contains 5 ppm of fluoride in it. Calculate the total daily fluoride consumption.

Case Study 2:

A person is consuming drinking water 4 lit/day, that water is containing 1 PPM of fluoride in it. He drinks tea three times a day (one cup is 50 ml), (Tea contains 32 PPM Fluoride), and calculates the total daily fluoride consumption.

Case Study 3:

A person is consuming drinking water 2 lit/day, that water is containing 3 PPM of fluoride in it. He drinks tea three times a day (one cup is 50 ml), (Tea contains 32 PPM Fluoride), he also eats foods containing black rock salt 3 gm per day (Black rock salt contains 157 PPM Fluoride) calculate the total daily fluoride consumption.

Case Study 4:

A person is consuming 2.5 lit/day, that water is containing 3 PPM of fluoride in it. He drinks tea five times a day (one cup is 50 ml), (Tea contains 32 PPM Fluoride), he also eats foods containing black rock salt 3 gm per day (Black rock salt contains 157 PPM Fluoride) and consume supari or pan masala (25 gm per day) (supari and pan masala contains 45 PPM Fluoride) calculate the total daily fluoride consumption.

Case Study 5:

A person is consuming drinking water 3 lit/day, that water is containing 3 PPM of fluoride in it. He drinks tea five times a day (one cup is 50 ml),, (Tea contains 32 PPM Fluoride), he also eats foods containing black rock salt 3 gm per day (Black rock salt contains 157 PPM Fluoride), consume supari or pan masala (25 gm per day) (supari and pan masala contains 45 PPM Fluoride) and sardines (200 gm per day) (small fishes contains 11 PPM Fluoride) calculate the total daily fluoride consumption.

5. **Debrief.** Ask participants what surprised them in the case studies, what are some important factors to consider other than safe limits in drinking water. Use probing question to help highlight the following factors:
    - Amount of water consumed (climate or profession)
    - Nutrition and Vulnerability (sick, elderly, pregnant, small children, undernourished)
    - Environmental Exposure (eg. air pollution)
    - Consumption of fluoride through other sources (medications, food, tea and coffee, dental and cosmetic products)
    - Presence of other contaminants or elements that aggravate impact of fluoride such as Heavy Metals (Lead, Arsenic, Cadmium, Mercury, etc.), High Nitrate (NO_3^-) & Sulfate (SO_4^{2-}), Acidic pH & High Sodium (Na^+).

Health risks due to these contaminants along with fluoride

Contaminant	Impact when combined with fluoride
Lead (Pb)	Worsens neurotoxicity, kidney damage and developmental issues
Arsenic (As)	Increases cancer risks, bone deformities, and organ toxicity
Cadmium (Cd)	Exacerbates kidney disease and weaken bones
Nitrate (NO_3^-)	Contributes to thyroid dysfunction and blood disorders
Low calcium (Ca)	Aggravates skeletal fluorosis and weaken bones
Low Magnesium (Mg)	Impairs detoxification, increase muscles and nerve disorders
Aluminium (Al)	forms neurotoxic fluoroaluminate complexes, linked to Alzheimer's

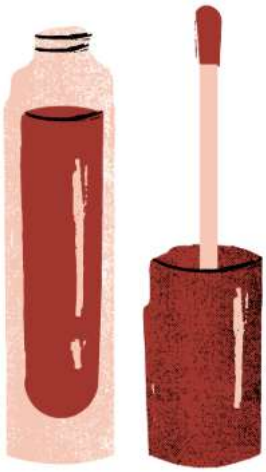
10 minutes

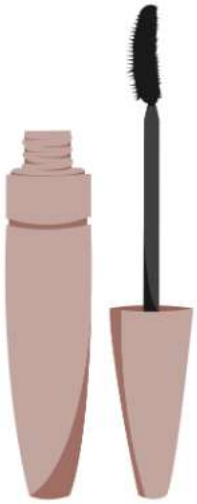
Review

1. Pair share: Participants pair up and discuss the following:
    - Have they ever come across symptoms that seem like fluorosis in communities that do not typically have high levels in their water?
    - If they do come across cases like this, what do they do?

Resources:

Opening Activity: List of items that contain fluoride






Blue
Natural + Medicine
Green
All Natural
Red
Natural + Chemical
Black
All Chemical

Slide 1: Fluoride ingestion from various sources

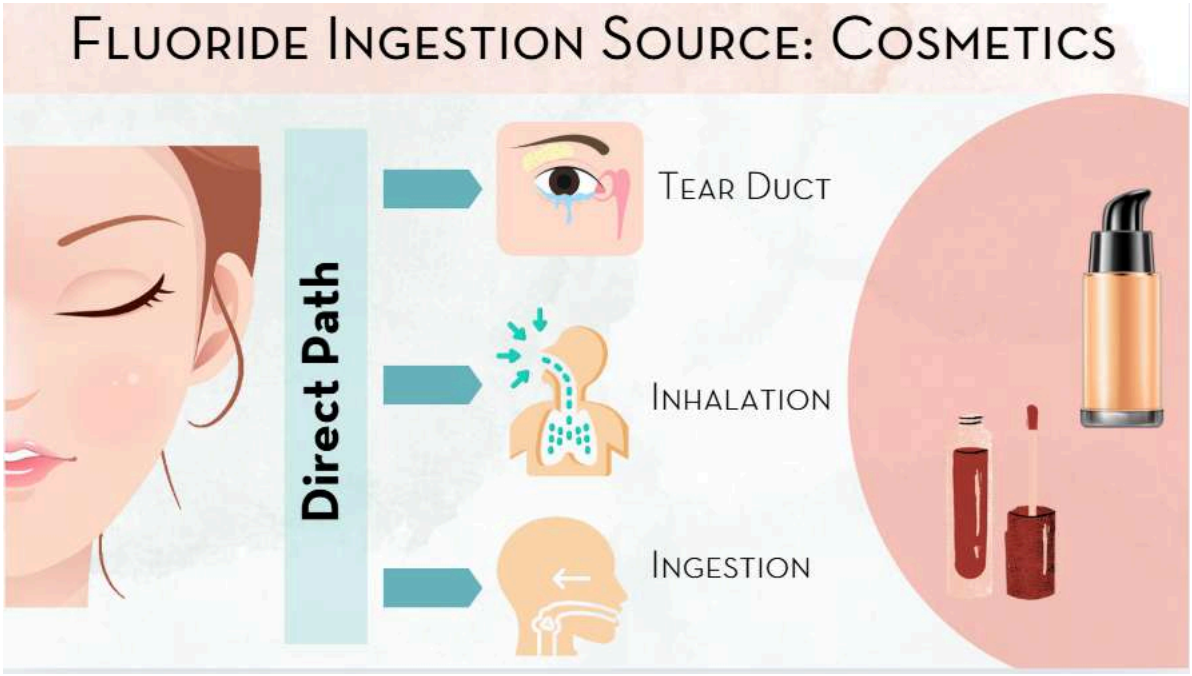
Armar is a 72 year old Tibetan. She greeted her visitors with a bottle of highland barley wine in her hand. As she tottered towards them they thought she might have had too much to drink. But when they began to talk they realized that she was not able to extend her arms, she moved stiffly and her joints appeared frozen. She explained that she couldn't even do her own hair, much less fetch a pail of water from the courtyard.

But what bothered Armar most of all was that for the last five years she had not been able to kneel down in front of the Buddha to show her piety. She knows many others like her suffering in similar ways from this mysterious affliction. They wondered if they were therefore unworthy of the Buddha's blessings now and after death. Now she doesn't even go into a temple. "If I can't show my respect for the Buddha, what's the point of visiting a temple?" she thinks.

She mentions this problem to her visitors who are community medicine practitioners, and wonders if this is the curse of old age. The community medical practitioners talk to a few other community members suffering from similar symptoms and note that some of them are much younger than Armar. Her visitors notice brownish-yellow staining on her teeth and decide to test her drinking water for fluoride. The fluoride test shows a healthy level of fluoride and the visitors are clueless, what could be causing her symptoms?

Slide 2: Discussion on dental products

Slide 3: Discussion on Cosmetic Products



Slide 4: Ram Story – Total fluoride intake

Ram, a diabetic, drinks unsweetened tea and avoids sweets and desserts, but his blood sugar remains high. His doctor asks about his diet, and Ram explains that he enjoys poha, parathas, samosas, and fresh fruit juice, thinking they are safe. The doctor explains that even though these foods don't taste sweet, they contain hidden sugars or carbohydrates that can spike blood sugar. The doctor also points out that the sweet tamarind chutneys Ram loves with his meals are full of sugar. Surprised, Ram realizes that even salty and natural foods can hide sugars. The doctor explained that consuming sugar in any form adds to the overall blood sugar levels, and its crucial to monitor sugar intake from all sources."

Slide 5: Amount of fluoride present in food

Amount of Fluoride Present in Food

Food	Mg per Serving	Food	Mg per Serving
Tea, black brewed, 1 cup	0.07-1.5*	Beef, cooked, 3 ounces	0.02
Coffee, brewed, 1 cup	0.22*	Tuna, light, canned in water, 3 ounces	0.02
Shrimp, canned, 3 ounces	0.17	Cheese, cheddar, 1 ½ ounces	0.01
Bottled water with added fluoride, 1 cup	≤0.17	Bread, white or whole wheat, 1 slice	0.01
Raisins, ¼ cup	0.08	Asparagus, cooked, 4 spears	0.01
Oatmeal, cooked, ½ cup	0.08*	Chicken, cooked, 3 ounces	0.01
Grapefruit juice, ¾ cup	0.08	Milk, fat-free or 1%, 1 cup	0.01
Potatoes, russet, baked, 1 medium	0.08	Apple, raw, with skin, 1 medium	0.01
Rice, cooked, ½ cup	0.04*	Avocado, raw, ½ cup sliced	0.01
Cottage cheese, ½ cup	0.04	Macaroni, plain, cooked, ½ cup	0.00*
Pork chop, baked, 3 ounces	0.03	Tomato, raw, 1 medium	0.00
Yogurt, plain, low-fat, 1 cup	0.03	Bananas, 1 medium	0.00
Lamb chop, cooked, 3 ounces	0.03	Egg, cooked, 1 large	0.00
Tortilla flour, 1 tortilla, approx. 10" diameter	0.02	Carrots, raw, 1 medium	0.00
Corn, canned, ½ cup	0.02	Peanut butter, 1 tbsp	0.00

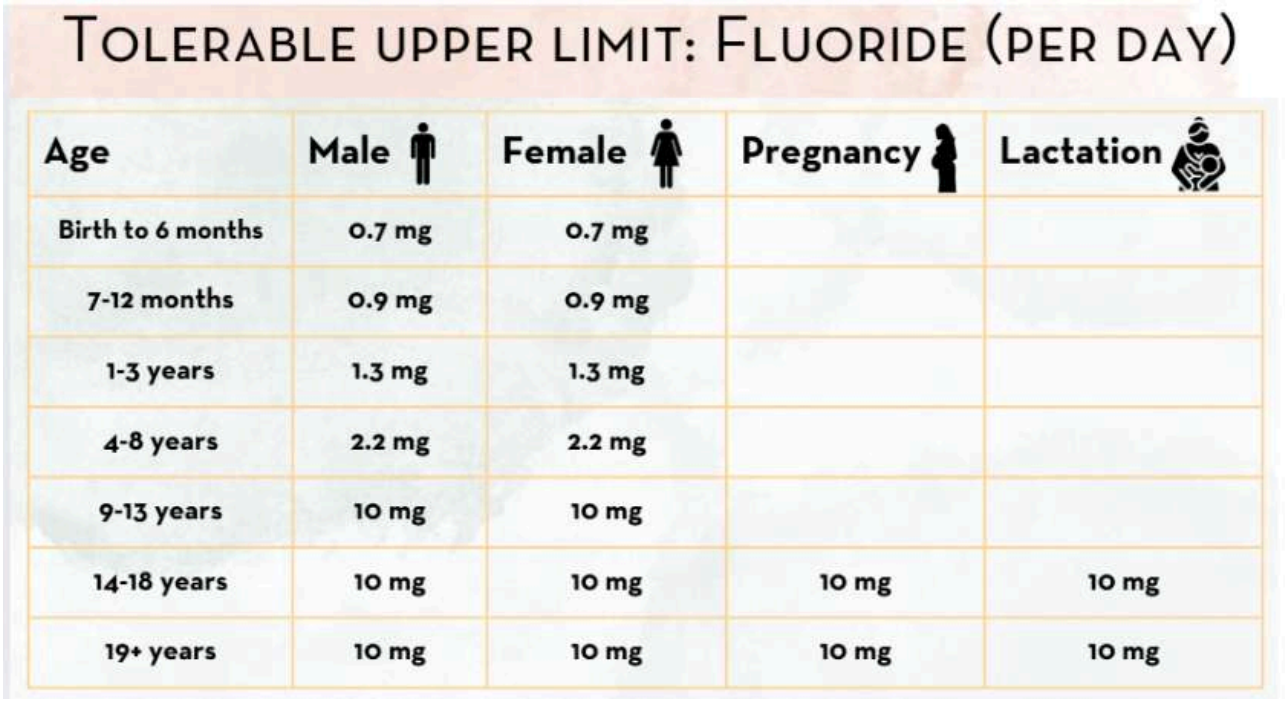
Slide 6: Adequate intake of fluoride (per day)

Adequate Intake of Fluoride (per day)

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months	0.01 mg	0.01 mg		
7–12 months	0.5 mg	0.5 mg		
1–3 years	0.7 mg	0.7 mg		
4–8 years	1 mg	1 mg		
9–13 years	2 mg	2 mg		
14–18 years	3 mg	3 mg	3 mg	3 mg
19+ years	4 mg	3 mg	3 mg	3 mg

Fluoride: Fact Sheet for Health Professionals (National Institute of Health, USA)
https://ods.od.nih.gov/factsheets/Fluoride-HealthProfessional/

Slide 7: Tolerable Upper Limit of Fluoride (per day)



Case Study 1:

	Per day	Fluoride Conc. (PPM)	Total daily Fluoride Consumption (mg)
Water consumption (L)	3	5	15
Total			15

Case Study 2:

	Per day (L)	Fluoride Conc. (PPM)	Total daily Fluoride Consumption (mg)
Water consumption	4	1	4
Tea consumption	0.15	32	4.8
Total			8.8

Case Study 3:

	Per day	Fluoride Conc. (PPM)	Total Fluoride Consumption (mg)
Water consumption	2 L	3	6
Tea consumption	0.15 L	32	4.8
Black rock salt consumption	3 gm	157	0.471
Total			11.271

Case Study 4:

	Per day	Fluoride Conc. (PPM)	Total Fluoride Consumption (mg)
Water consumption	2 L	3	6
Tea consumption	0.15 L	32	4.8
Black rock salt consumption	3 gm	157	0.471
Supari/ Pan Masala	25 gm	45	1.125
Total			12.396

Case Study 5:

	Per day	Fluoride Conc. (PPM)	Total Fluoride Consumption (mg)
Water consumption	2 L	3	6
Tea consumption	0.15 L	32	4.8

Black rock salt consumption	3 gm	157	0.471
Supari/ Pan Masala	25 gm	45	1.125
Sardines small fish	200 gm	11	2.2
Total			14.596

85 minutes total

Lesson Plan

Fluorosis and its Types

Lesson Purpose

To encourage participants to make the link between fluoride and fluorosis.

Learning Outcomes

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

1. Identify types of fluorosis
2. Identify and explain the diagnostic criteria for fluorosis, including key symptoms and diagnostic tests.

Materials

- Whiteboard/flipchart
- Marker
- Flash cards of fluorosis types
- Flash cards of fluorosis diagnosis
- Calcium-fluoride binding diagram
- Sticky notes

Preparation

- Write down the instructions of the race activity on the pieces of paper
- Print factsheets:
    i. Types of Fluorosis
    ii. Fluoride related condition for each patient
    iii. Fluoride related health condition for doctors
- Prepare PowerPoint with:
    i. Fluoride Flow in Human Body
    ii. Dental, skeletal, and non-skeletal fluorosis facts
    iii. Diagnosis symptoms
    iv. Diagnosis tools

10 minutes

Introduction

1. Explain to the participants that now they are going to have a race.
2. Each participant will receive a paper containing specific instructions for following a race. They **must not** share their instructions with anyone; everyone should keep them to themselves.
    - If a participant receives a paper without instructions, it means they have no instructions to follow.
3. Based on the instructions on your paper, you will need to find your partner having the same instruction. Participants with the same instructions will pair up. *For example, if you have the instruction to 'hold hands but face opposite directions', you will look for someone else who has the same instruction, and the two of you will pair up.*
    - Some typical instructions are as follows:
        i. **Holding both hands but facing the opposite side**: You will hold hands with your partner while facing away from each other.
        ii. **Linking arms but facing opposite sides**: You will link arms with your partner side by side while facing the opposite direction.
        iii. **Stand side by side will move sideways holding hands**: You will stand side by side with your partner and move sideways together holding hands.
        iv. **Three-legged race**: You will tie one leg together with your partner and move as a three-legged pair.
        v. **Keeping one hand on the head of the partner**: each one person will keep their hand on their partner's head while moving.
        vi. **Holding hands and jumping forward**: You will hold hands with your partner and move forward by jumping together.
        vii. **Running sideways**: Both partners will run sideways together as fast as possible.
        viii. **Walking with a balloon between your backs**: Place a balloon between your partner's back (without using your hands) and move together without letting the balloon fall.
        ix. **Marching together**: You and your partner must walk together in unity and keep pace with each other while shouting left right which leg is forward.

Trainer Note:

The objective is for each participant to follow their instructions and finish the race as quickly as possible. If the number of participants is large, the instructions may be repeated to ensure everyone understands.

4. Explain that when participants are paired, it creates a restriction that hinders their ability to complete the race, leading to stress and negative impact. On the other hand, when there is no pairing, participants face no such limitations, allowing them to proceed without hindrance.
5. The concept can be compared to the analogy of fluoride ions:
    - **No pairing:** Fluoride ions are free, unbounded, and unrestricted
    - **Pairing:** Fluoride ions are bonded with calcium and magnesium, creating a restricted form
6. Define fluorosis:
    - When fluoride binds with Calcium and Magnesium in our body parts (bone, skin, muscles, cells) and causes different symptoms such as stress, strain, and/or restricted mobility this is called fluorosis.
    - Calcium and Magnesium is present in our body in teeth, bones, blood, muscles, nervous system (at synaptic terminals: junctions where neurons and other excitable cells transfer information).
7. Explain that in this lesson they will be learning about the fluorosis types.

40 minutes

Types of Fluorosis

Objective: Discuss the types of fluorosis and the importance of an early diagnosis.

1. Ask the participant to write down, on a sticky note, all the symptoms of fluorosis they know or have experienced.
2. Once everyone is done writing, collect all the sticky notes.
3. Place the symptoms into three categories:
    - Dental Fluorosis
    - Skeletal Fluorosis
    - Non-Skeletal Fluorosis
4. Explain to participants that now they will know the process of fluoride ingestion in the human body. This will help them to know how fluoride accumulates in the body and causes damage. Show the ‘Fluoride Flow in Human Body’ through PPt (slide 1) and discuss:
    - Entry of fluoride from source to human body
    - Flow of fluoride within human body
    - Accumulation in and excretion from the body (aid for pathological diagnosis)

Trainer Note:

Fluoride flow in the human body

Fluoride is naturally present in soil and rocks, and it can be transferred into water, crops, food, or grains that are consumed by humans or animals. Once ingested through the oral cavity, fluoride accumulates in the stomach and is absorbed, making its way to the small intestine. From the small intestine, fluoride enters the bloodstream, where it circulates in the plasma.

A portion of this fluoride is excreted through urine and sweat, while the remaining fluoride remain in body and affects teeth, and bones. The accumulation of fluoride in bones can lead to skeletal fluorosis, and its reaction in teeth can cause dental fluorosis.

5. Use the PPT and distribute fluorosis factsheet to show the overview of three types of fluorosis and their characteristics:
    - **Dental fluorosis:** affects the teeth, causing discoloration and enamel damage (slide 2).
    - **Skeletal fluorosis:** affects the bones, leading to pain and joint stiffness (slide 3).
    - **Non-skeletal fluorosis:** involves soft tissues, organs, and systems causing muscle weakness and other symptoms (slide 4).
6. Ask the group, if they have observed any symptom of fluorosis they learned from the discussion.
7. Explain that there are ways that influence the severity of fluorosis like the amount of exposure, individual vulnerability, stage of disease and age at exposure.
    - **Amount of fluoride exposure:** The severity of fluorosis is directly related to the level of fluoride exposure, particularly when fluoride intake exceeds the optimal range.
    - **Individual vulnerability:** Some people are more sensitive to fluoride due to genetic variation. Individuals with certain medical conditions like kidney disease, may be more vulnerable to fluoride toxicity as their bodies have reduced ability to extract excess fluoride.
    - **Stage of disease:** In early stages of fluorosis, it is possible to reverse by proper care, nutrition and reduced fluoride exposure/ intake.
    - **Age at factors:** The severity of fluorosis is greatest when exposure occurs during the developmental stage (typically from birth to 6 years).
8. Explain to participants that the early stage of dental and skeletal fluorosis could be diagnosed through some tests. Display the diagnosis symptoms on PPt (slide 5). If time permits, have few participants to perform the diagnosis tests.

30 minutes

Diagnosing Fluoride-related Conditions (Roleplay)

Objective: Recognize the key symptoms and causes of fluorosis in individuals.

1. Explain to the participants that now they will be doing the role play. They will be stimulating the medical scenario where there will be 6 volunteers as "**Patients"** and the remaining participants will form 6 panels of "**Doctors".**
2. Ask 6 volunteers to step up and assign them each a patient role.
    - Patient 1: Dental fluorosis
    - Patient 2: Poor dental hygiene (cavities)
    - Patient 3: Skeletal fluorosis
    - Patient 4: Arthritis
    - Patient 5: Non-skeletal fluorosis
    - Patient 6: Gastrointestinal infection
3. The remaining participants will be divided into 6 groups and act as "**Doctors".**
4. Distribute a fact sheet on fluoride-related conditions to each doctor group. The fact sheet must include key symptoms, causes, and diagnosis tips related to fluorosis.
5. Each patient will rotate through the doctor groups every 5 minutes. Patients are requested to stay in character and answer questions related to the symptoms only.
6. The doctors will ask relevant questions and try to diagnose the condition using the fact sheet.
7. After each diagnosis, the doctors should write their diagnosis and Doctors Group Number on a slip of paper.

Trainer Note:

Ensure that the patients remain in character and assist the doctor if needed. After 5 minutes, ensure that each patient moves on to the next group.

8. Once all the patients have rotated through all the doctor groups, discuss in the larger group.
9. Ask each group to share their diagnosis of each patient. Patients should reveal if the diagnosis was correct or not.

Optional: Confirmatory diagnosis of fluorosis

1. Introduce diagnosis tools for confirming cases of fluorosis use PowerPoint (Slide 6).
    - Blood Serum Test: Used to measure **fluoride levels** in the blood
    - Urine Test: Measures **fluoride excretion** through urine
    - X-ray Test: Reveals **calcification in the interosseous membrane** and **deformities**

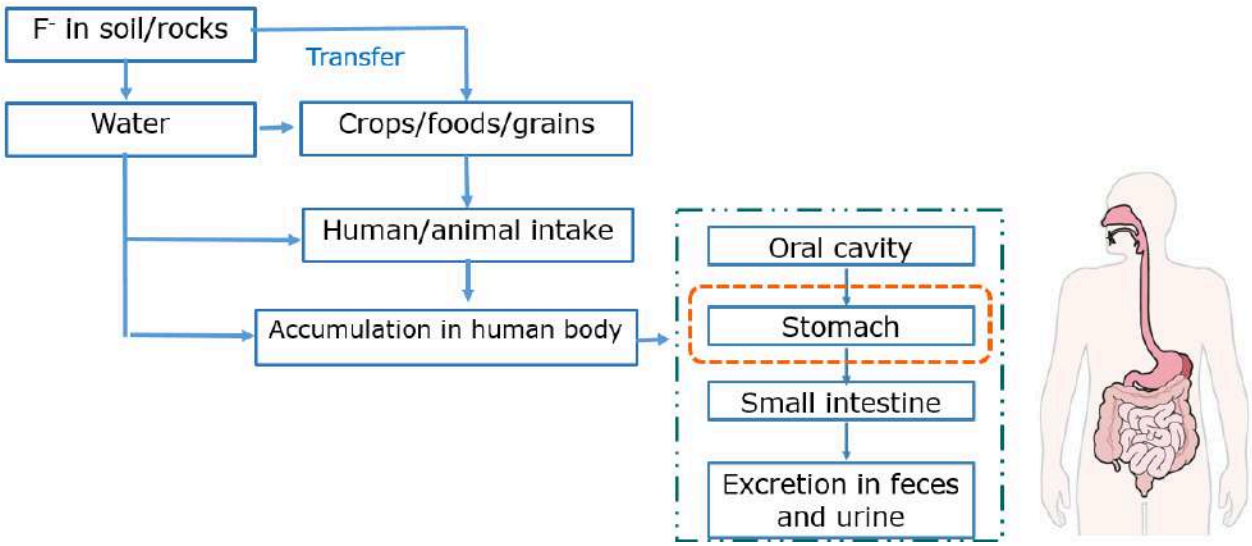
5 minutes

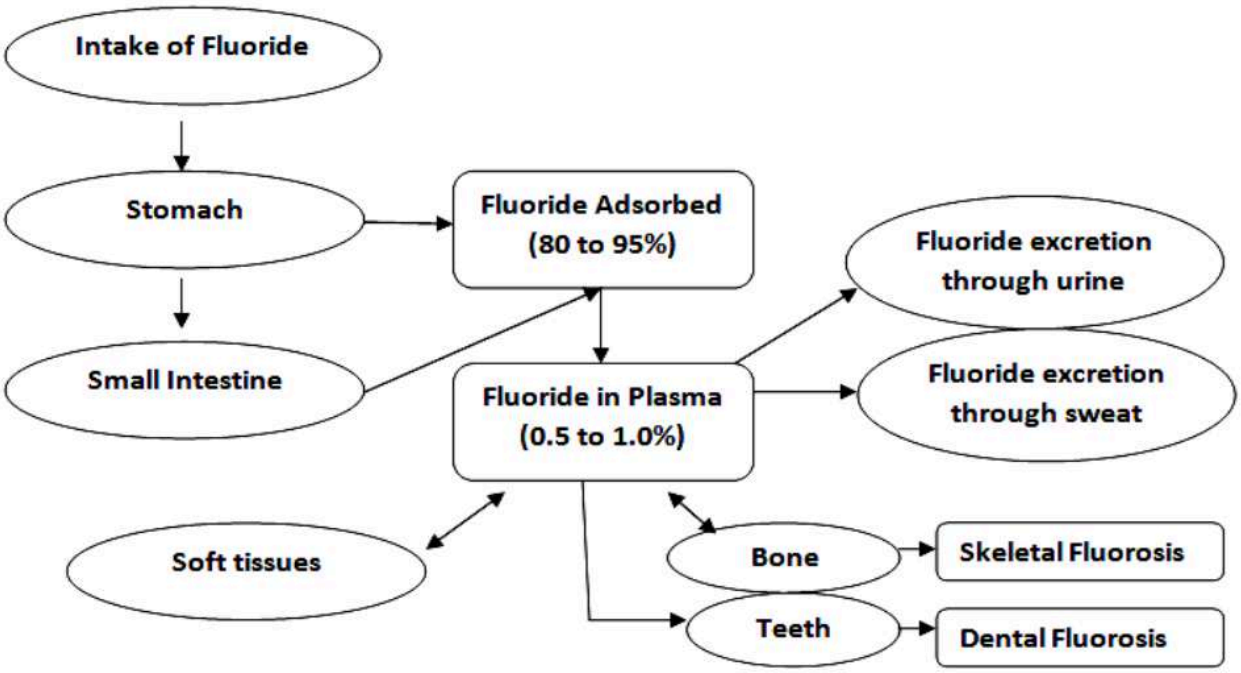
Review

1. Pair share: Are you surprised at the level of impact from fluoride? Why or why not?

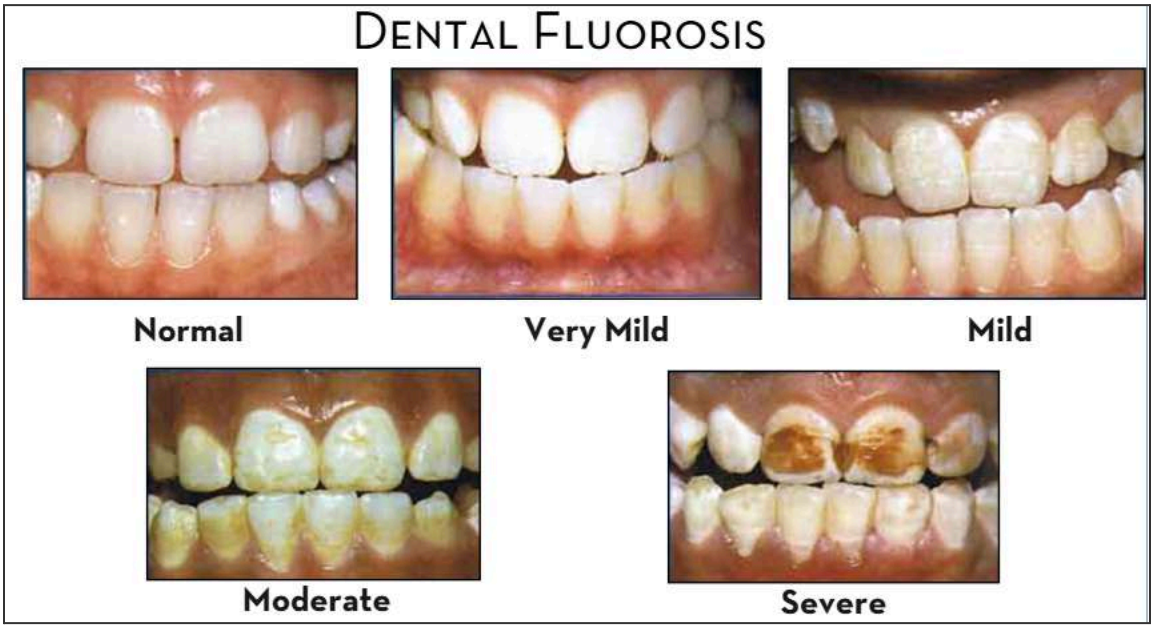
Resources:

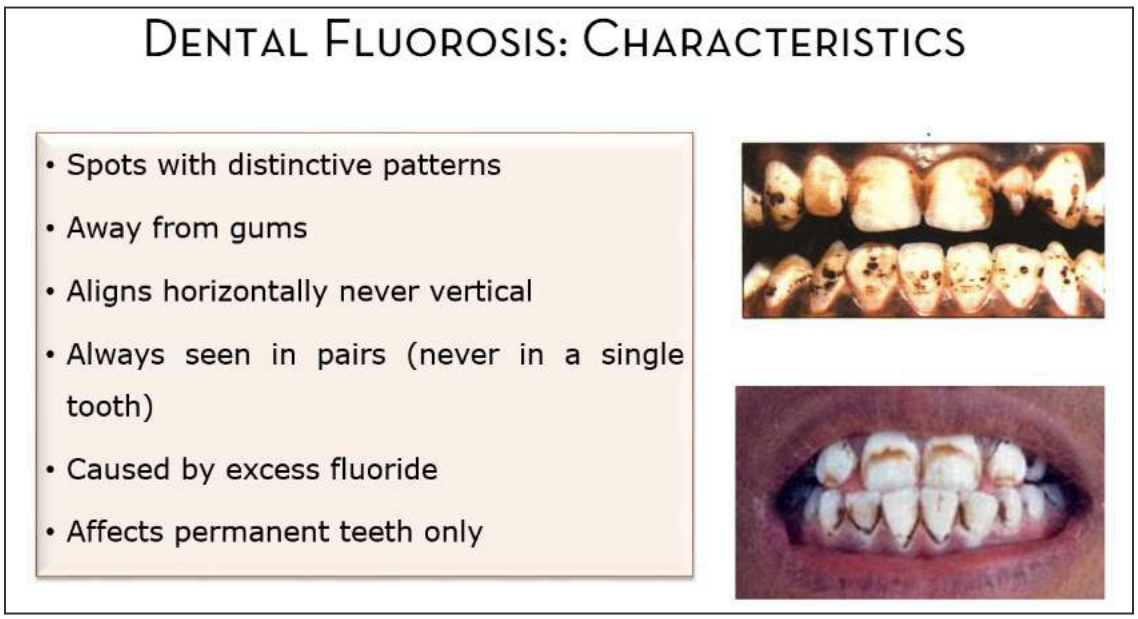
Slide 1: Fluoride Flow in Human Body



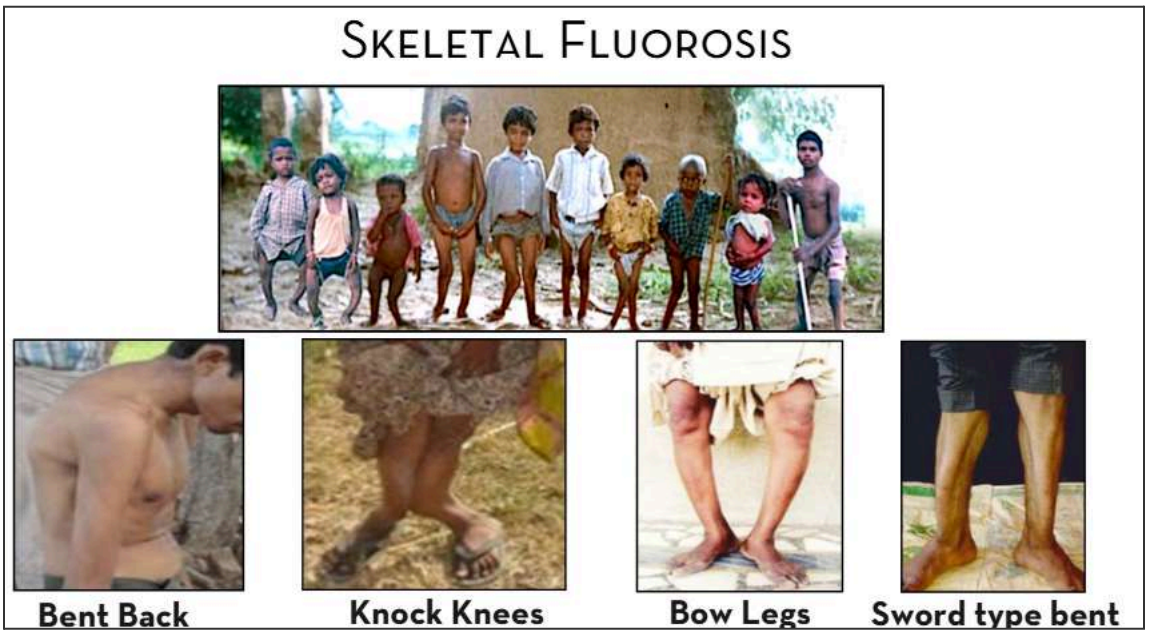


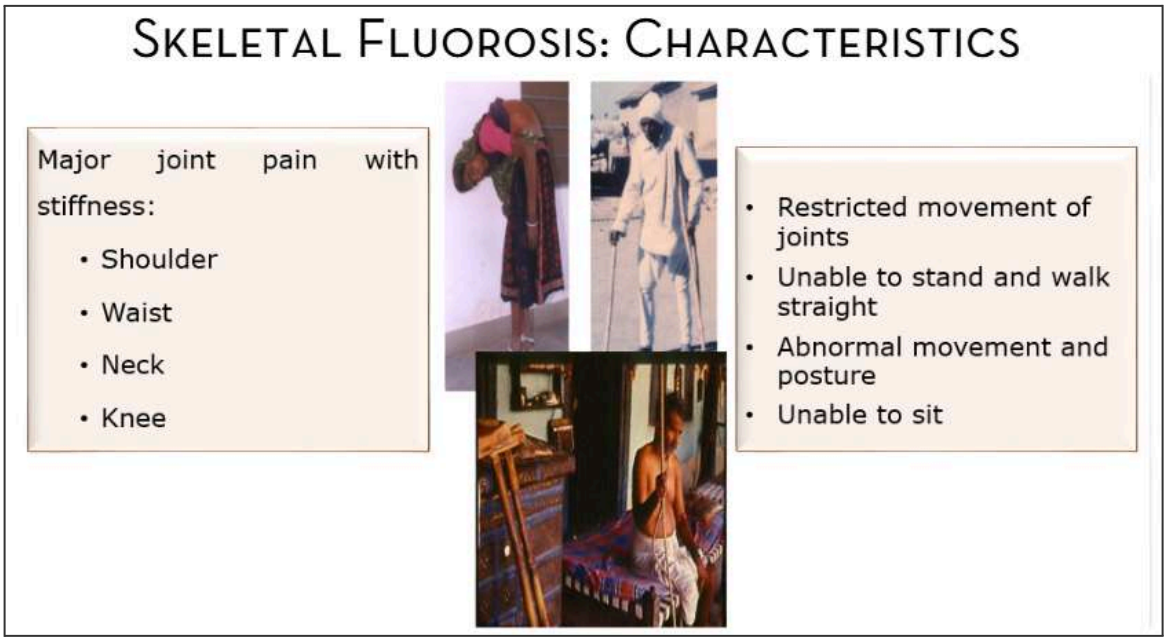
Slide 2: Overview of three-types of fluorosis



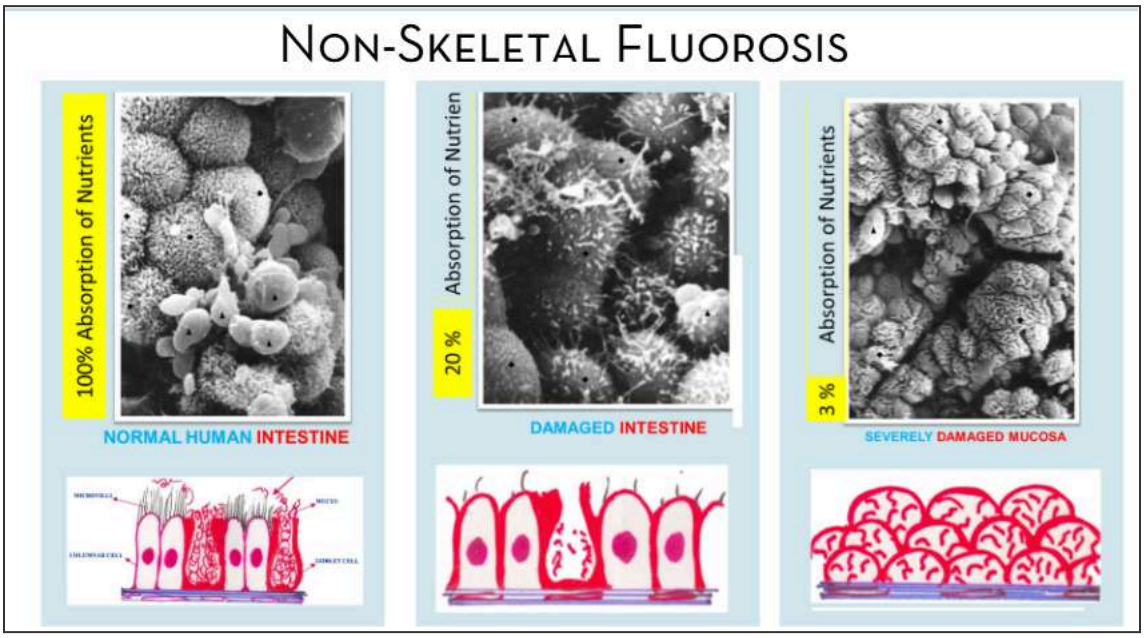


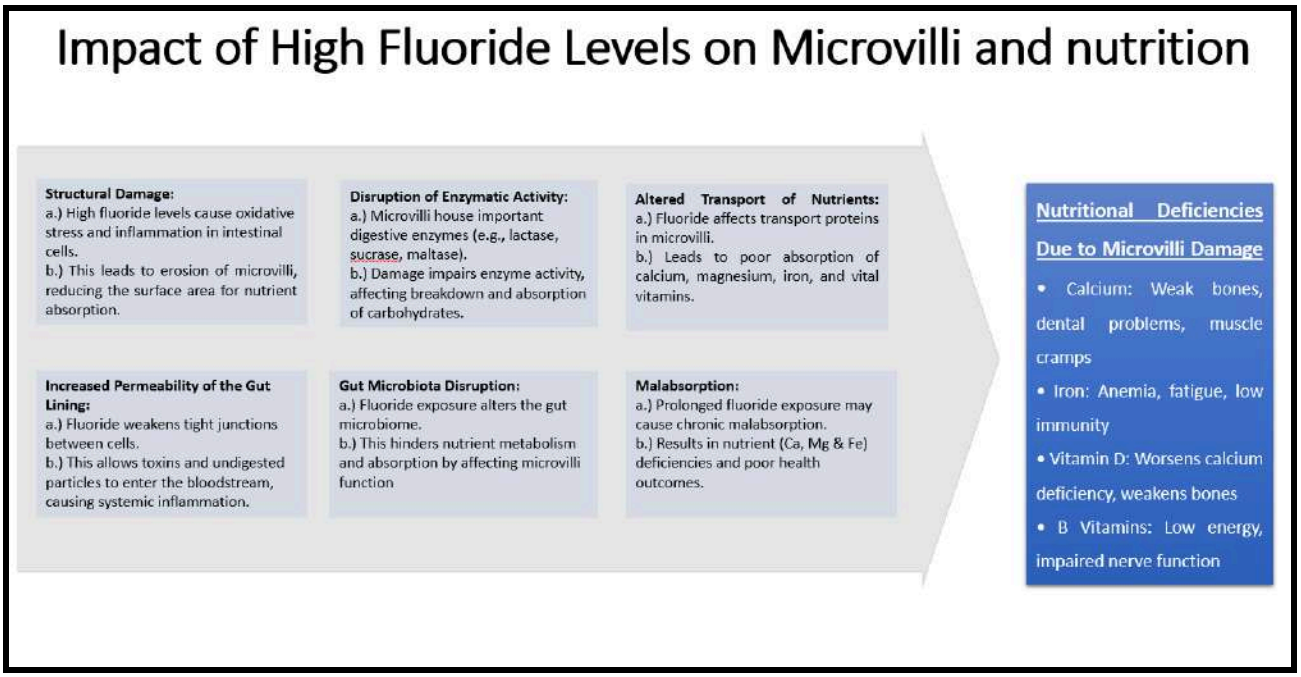
Slide 3:


SKELETAL FLUOROSIS
Bent Back
Knock Knees
Bow Legs
Sword type bent

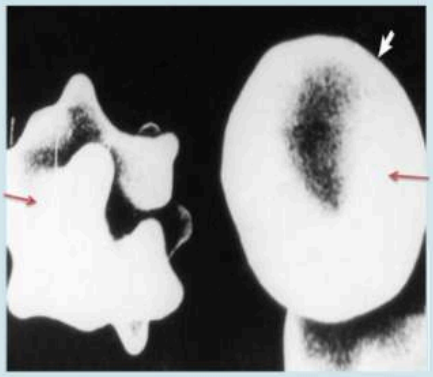

SKELETAL FLUOROSIS: CHARACTERISTICS
Major joint pain with stiffness:
• Shoulder
• Waist
• Neck
• Knee
• Restricted movement of joints
• Unable to stand and walk straight
• Abnormal movement and posture
• Unable to sit

Slide 4: Explanation of how fluoride affects microvilli and nutrition

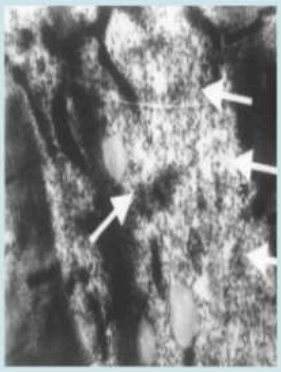




Non-Skeletal Fluorosis: Characteristics



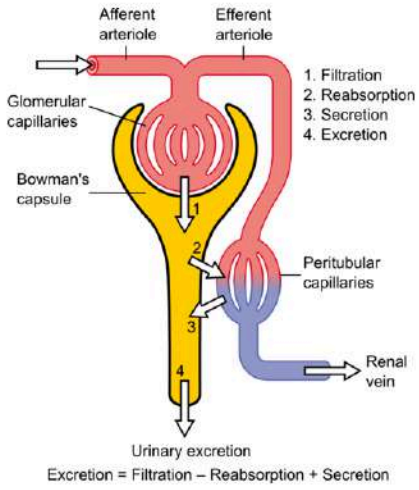
- Weakness
- Fatigue
- Low Hemoglobin
- Depression



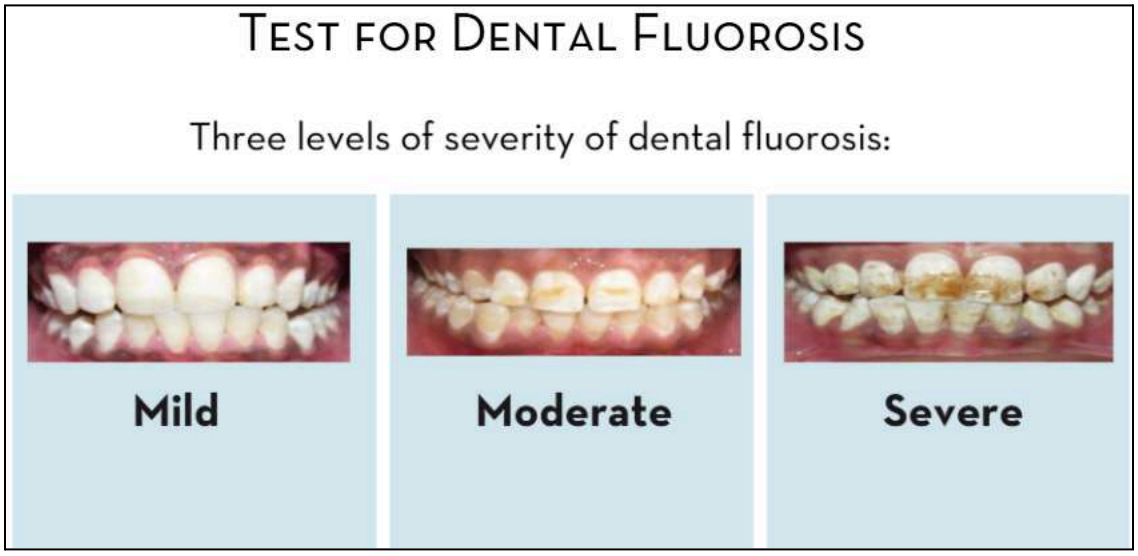
- Leg Pain
- Trouble walking
- Muscle weakness and fatigue

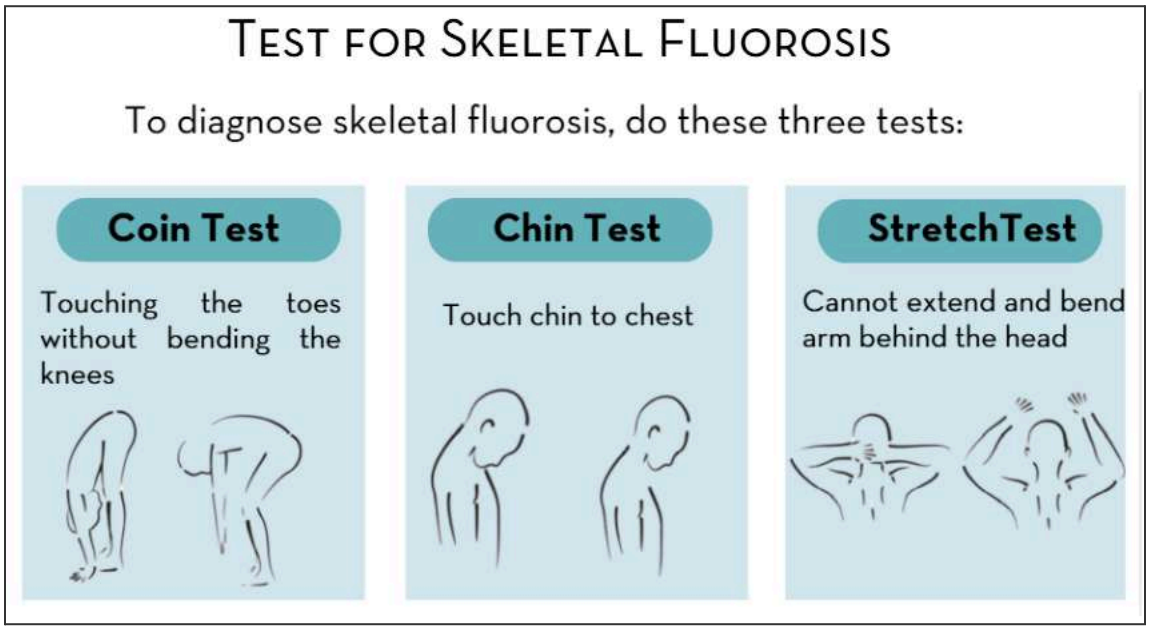
Impact of Fluoride: Soft tissues, Renal Function and Urinary Flow

- **Fluoride Accumulation in Soft Tissues**
  - Leads to calcified deposits in non-skeletal tissues
- **Renal Excretion Impairment**
  - Alters glomerular filtration rate
  - Impacts tubular reabsorption
  - Results in disturbed urinary flow patterns
- **Systemic Consequences**
  - Impaired detoxification
  - Potential fluid imbalance
  - Increased fluoride retention in the body



Slide 5:


TEST FOR DENTAL FLUOROSIS
Three levels of severity of dental fluorosis:
Mild
Moderate
Severe


TEST FOR SKELETAL FLUOROSIS
To diagnose skeletal fluorosis, do these three tests:
Coin Test
Touching the toes without bending the knees
Chin Test
Touch chin to chest
StretchTest
Cannot extend and bend arm behind the head

Fluorosis: Fact Sheet

This fact sheet provides an overview of the different types of fluorosis, their causes, and symptoms, aimed at helping individuals identify and understand the impacts of excessive fluoride exposure.

1. Dental Fluorosis

Overview:

Dental fluorosis occurs during the development of teeth among children, typically when they consume water or use toothpaste with high fluoride content. It affects permanent teeth before the enamel is fully formed and is irreversible.

Key Characteristics:

- Opaque white teeth with horizontal stains (yellow, red, or brown) away from the gums
- Distinctive spots with patterns
- Stains align horizontally, never vertically
- Stains are always seen in pairs of teeth "bilateral symmetry" (never affecting a single tooth)
- Affects only permanent teeth

2. Skeletal Fluorosis:

Overview:

Skeletal fluorosis is caused by excess fluoride intake through food and water. It leads to joint stiffness, joint pain, and changes in bone structure. Bigger joints (knee and elbow) are affected first and then smaller (fingers). This can be reversible at a young age. In severe cases, it can result in neurological issues and paralysis.

Key Characteristics:

- Early symptoms:
    - Stiffness and pain in joints
    - Fluoride buildup in the body interferes with bone structure and calcium absorption in the bones
    - Stiffness of ligaments causing muscle pain
- Severe Symptoms:
    - Bone deformities and inhibited bone growth
    - Neurological problems, restricted joint movement, abnormal posture, and difficulty standing or walking straight
    - Inability to sit or move normally
- Affected Joints:

- Shoulder
- Waist
- Neck
- Knee
- Elbow

3. Non-Skeletal Fluorosis:

Overview:

Non-skeletal fluorosis manifests in symptoms that are often difficult to detect and can lead to misdiagnosis. These symptoms often appear before dental and skeletal fluorosis and can serve as early warning signs.

Key characteristics:

- Early Symptoms:
  - Gastrointestinal discomfort, weakness, fatigue, and joint pain.
  - Often overlooked due to the misconception that fluoride only affects bones and teeth.
- Neurological Manifestations:
  - Nervousness, depression, tingling sensations in fingers and toes.
  - Excessive thirst and frequent urination.
  - Adverse effects on brain control and development.
- Muscular Manifestations:
  - Muscle weakness and stiffness, pain, and loss of muscle power.
- Allergic Manifestations:
  - Painful skin rashes (perivascular inflammation), prevalent in women and children.
  - Pinkish-red or bluish-red spots on the skin that clear up within 7-10 days.
- Gastro-Intestinal Problems:
  - Acute abdominal pain, diarrhea, constipation, and blood in stool.

Fact Sheet: Role Play- Diagnosing the fluoride-related condition (Patient)

Patient 1: Dental Fluorosis

Symptoms:

- Teeth have white streaks or spots on the enamel
- Some teeth may have brown stains or areas of discoloration
- No pain or discomfort from the teeth
- Drinking fluoridated water daily, and having consumed fluoride toothpaste in excess as a child.

Patient 2: Poor Dental Hygiene- Cavities

Symptoms:

- Pain when eating sugary or cold foods
- Visible holes or decay on the teeth, especially molars
- Bad breath and general mouth odor
- Have not been to the dentist in years, and brushing habits are inconsistent
- Occasionally, gums bleed when brushing

Patient 3: Skeletal Fluorosis

Symptoms:

- Joint pain, especially in the knees and hips
- Stiffness and limited mobility in the joints
- Lived in a high-fluoride region for years and consumed water with high fluoride levels for an extended period
- Difficulty standing up after sitting for long periods

Patient 4: Arthritis

Symptoms:

- Joint swelling, particularly in the fingers, knees, or elbows
- Pain and stiffness in the joints, especially in the morning
- Difficulty performing activities like opening jars or walking upstairs
- Family history of arthritis, but no history of excessive fluoride exposure

Symptoms:

General **Patient 5: Non-Skeletal Fluorosis**

- Fatigue, weakness, and headaches
- Difficulty concentrating and memory lapses
- Skin discoloration, with patches of darker skin on the elbows and knees
- No joint pain or swelling, but you have a history of drinking water from a fluoridated source for many years

Patient 6: Gastrointestinal Infection

Symptoms:

- Nausea, vomiting, and occasional diarrhea
- Stomach cramps and bloating after eating
- You've been traveling recently and suspect food or waterborne infection
- No history of excessive fluoride exposure

Fluoride-related health condition: Fact sheet for Doctors

1. **Dental Fluorosis**

Symptoms:

- Discoloration of teeth: Teeth may appear yellow, brown, or have white patches.
- Mottling or pitting: Teeth may have visible stains, lines, or surface damage.
- Chalky or opaque appearance: Teeth may look more opaque than normal, with some areas being more visible than others.
- Severe cases: Enamel may be chipped or pitted, leading to weakened teeth.

Causes:

- Excessive fluoride intake during childhood (typically during tooth development).
- Overuse of fluoride toothpaste, drinking fluoridated water, or excessive fluoride treatments.

Diagnosis Tips:

- Ask about the patient's history of fluoride use, particularly during childhood.
- Look for visible signs of discoloration or pitting on the teeth.
- Check for any history of excessive fluoride exposure (e.g., living in an area with high fluoride levels in drinking water).

2. **Poor Dental Hygiene (Cavities)**

Symptoms:

- Tooth pain: Persistent pain, especially when eating or drinking hot, cold, or sugary foods.
- Visible cavities: Dark or black spots or holes on teeth.
- Sensitive teeth: Pain or discomfort when consuming hot, cold, or sweet food.
- Bad breath (halitosis): Chronic bad breath due to bacteria from decaying teeth.
- Gum inflammation or bleeding.

Causes:

- Inadequate brushing and flossing.
- High sugar intake.
- Lack of regular dental checkups.
- Dry mouth (xerostomia) or low saliva production.
- Infrequent professional cleanings or fluoride treatments.

Diagnosis Tips:

- Ask if the patient has regular dental checkups and if they experience pain or sensitivity.

- Inquire about their brushing habits and diet (particularly sugar consumption).
- Look for visible signs of decay or dental cavities in the mouth.

3. Skeletal Fluorosis

Symptoms:

- Joint pain: Stiffness, swelling, and discomfort, particularly in the knees, elbows, and spine.
- Limited joint mobility: Difficulty in moving certain joints due to pain or calcification.
- Bone deformities: Changes in bone structure, which may be visible on X-rays.
- Bone stiffness: A feeling of tightness or rigidity in the bones.
- Calcification: Abnormal bone deposits (Calcification in the Interosseous Membrane) or thickening around joints and ligaments.

Causes:

- Chronic exposure to high levels of fluoride over many years (often through drinking water, occupational exposure, or excessive fluoride consumption).
- Fluoride accumulation in the bones, causing damage to bone density and structure.

Diagnosis Tips:

- Ask about the patient's exposure to high levels of fluoride, including water, occupational exposure, or prolonged use of fluoride-containing supplements.
- Inquire about a history of joint pain, stiffness, and bone problems.
- Request X-rays to confirm any bone changes, calcification, or joint deformities.

4. Arthritis

Symptoms:

- Joint pain, reddishness and swelling: Pain, especially in the knees, wrists, or fingers, along with inflammation.
- Stiffness: Difficulty moving affected joints, particularly after rest.
- Decreased range of motion: Reduced ability to move joints fully due to swelling or pain.
- Fatigue: General tiredness, particularly when symptoms worsen.

Causes:

- Autoimmune diseases (e.g., rheumatoid arthritis).
- Wear and tear on joints over time (e.g., osteoarthritis).
- Genetic factors, infections, or previous joint injuries.

Diagnosis Tips:

- Ask about pain patterns, including the joints affected and any history of trauma.
- Inquire about symptoms such as morning stiffness, swelling, or changes in joint mobility.
- Laboratory tests and X-rays can help confirm the diagnosis and distinguish it from other conditions like skeletal fluorosis.

5. Non-Skeletal Fluorosis

Symptoms:

- Digestive issues: Nausea, vomiting, abdominal pain, diarrhea, and constipation.
- Skin problems: Rashes, itchiness, or discoloration.
- Headaches: Frequent or recurring headaches without a clear cause.
- Fatigue: Unexplained tiredness, low energy levels.
- Weakness in limbs: Tingling or weakness in the arms and legs.

Causes:

- Excessive fluoride intake, typically from drinking high-fluoride water or ingestion of fluoride-containing substances.
- Can affect multiple body systems, including the gastrointestinal and nervous systems.

Diagnosis Tips:

- Ask about fluoride exposure (e.g., water source, fluoride-containing products).
- Inquire about gastrointestinal symptoms such as nausea or diarrhea.
- Pay attention to reports of fatigue, skin rashes, or headaches that don’t resolve with standard treatments.
- Blood tests and urine tests may help detect high fluoride levels in the body.

6. Gastrointestinal Infection

Symptoms:

- Stomach cramps: Abdominal pain or discomfort, especially around the stomach area.
- Diarrhea: Loose, watery stools, possibly with mucus or blood.
- Vomiting: Frequent or intense nausea leading to vomiting.
- Fever: Elevated body temperature, often accompanying infection.
- Fatigue: General weakness or tiredness due to illness.

Causes:

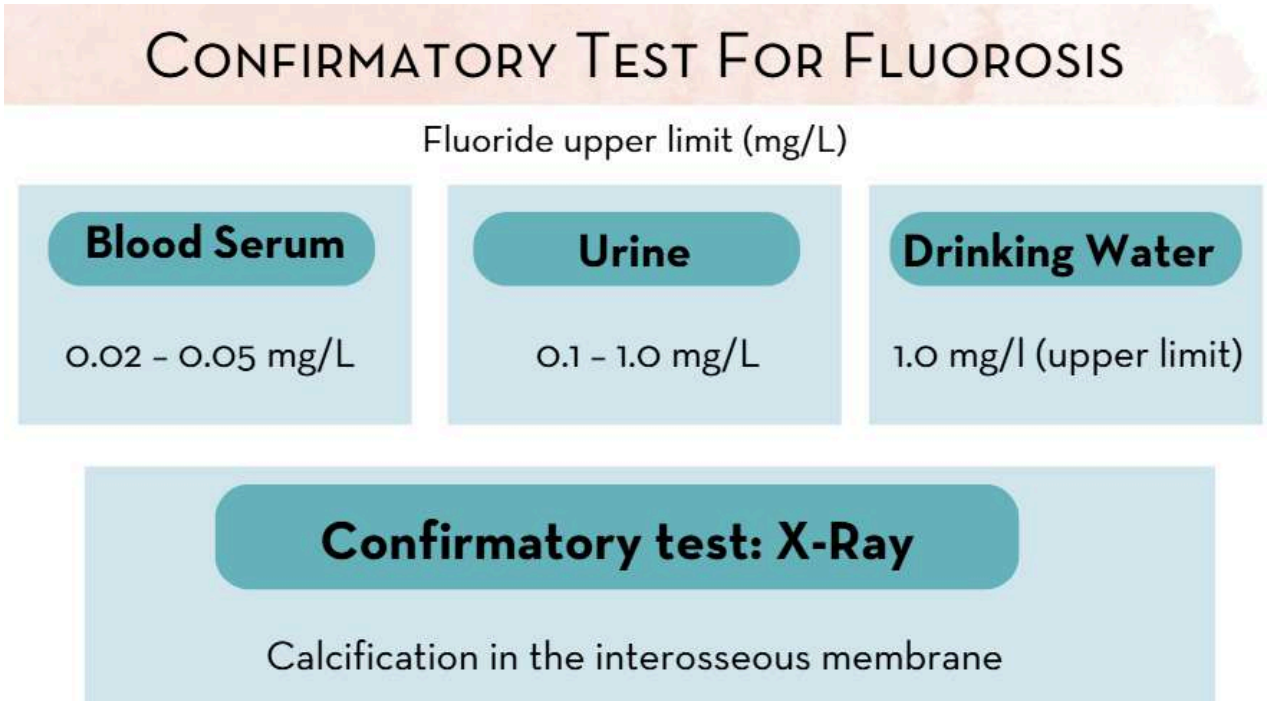
- Bacterial or viral infections, such as food poisoning, rotavirus, or E. coli.
- Parasite infections (e.g., Giardia).

- Contaminated food or water, poor sanitation, or unclean hands.

Diagnosis Tips:

- Ask about the patient's recent eating habits (e.g., any foodborne illness outbreaks).
- Inquire about the onset of symptoms, including when vomiting or diarrhea started.
- Check for any recent travel or exposure to unclean water or food sources.
- Stool tests may be necessary to identify the specific pathogen causing the infection.

Slide 6: Confirmatory test for fluorosis



70 minutes total

Lesson Plan

Prioritizing Health Concerns

Lesson Purpose

To encourage participants to prioritize water-related health concerns in a community.

Learning Outcomes

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

1. Explain how the exposure to fluoride during first 1000 days of life is a critical period in development List the ways communities can be impacted by fluorosis
2. Prioritize water-related health concerns in a community to sensitize communities

Materials

- Whiteboard/flipchart
- Sticky notes
- Marker
- Flash cards of fluorosis types
- Fluorosis diagnosis flash card
- Calcium-fluoride binding diagram
- 1000-day scenario handout

Preparation

- Write learning outcomes on flipchart paper
- Prepare 5 flip chart papers with the following headings:
    - Economic burden
    - Lack of opportunity
    - Social stigma
    - Strain on the medical system
- Print out copies of the *Community Health Prioritization Table* (1 per group)
- Prepare PowerPoint with:
    - Fluoride and 1000 days impact for pregnant mother
    - Fluoride and 1000 days impact for infant/child

15 minutes

Hook/Introduction

Objective: Understand the impact of fluoride exposure during the first 1000 days of life.

1. Divide the participants into four small groups. Each group will receive a scenario card (Kunti's Story).
2. Explain to the participants that they will explore how fluoride exposure during the first 1000 days of life affects a child's growth and development.
3. Display the following question one by one on PPT and ask the participants to highlight the possible health outcomes in the larger group.
    - How do you think early childhood exposure to fluoride can impact their growth and development?
        i. *Fluoride interferes with development of teeth, leading to dental fluorosis. The exposure may also affect the bone development leading to skeletal fluorosis. Additionally, cognitive development is also impacted.*
    - Why do you think children are at a higher risk of developing fluorosis?
        i. *Children are more vulnerable because their teeth and bones are still forming. Their smaller size might mean they are consuming more fluoride per unit of body weight than adults.*
    - What consequences could this have on the child's future?
        i. *Long-term exposure may lead to developmental delays, cognitive impairment, or physical disabilities. Fluorosis could affect a child's self-esteem, academic performance, and social interaction.*
    - What impact could this have on the family and community?
        i. *Families may face financial stress due to medical treatments. Communities could see a rise in healthcare costs and a potential decrease in loss of opportunities due to fluorosis and overall quality of life.*
4. Explain the importance of the first 1000 days (from conception to age 2) and display the slides on PPT (slide 1 and 2)
    - A critical period for **human development**. During this period the foundation of **physical health** and **cognitive abilities** are established.
    - During the development of the brain and body, chemicals like fluoride can cause long-term impacts.
5. Explain why fetuses and children under 2 have a higher risk of developing fluorosis, even with less exposure.
    - **Fetuses** are vulnerable because their organs are still forming and are dependent on the mother's body.
    - **Infants** under 2 years of age have a high absorption rate of fluoride because their kidneys and liver are not fully developed to flush out toxins.

- Fluoride exposure in the early years may have a broader cognitive impact, affecting **learning ability**, **behavior**, and **IQ**.

Trainer's Note:

Explain to participants:
The first 1000 days (conception to age 2 yrs) is a **critical period** for brain development, organ formation, and overall health. Exposure to high levels of fluoride during this period can have long-lasting negative effects, particularly on neurological, skeletal, and dental health.

1. **Neurological & Cognitive Development**: It is Most Critical Impact causing Lower IQ & Cognitive Deficits and Alters Neurotransmitters & Brain Structure

2. **Skeletal Development & Growth**: Weaker/deformed Bone Formation and Delayed Growth & Low Birth Weight

3. **Dental Fluorosis** (Visible Before Age 2): Milk and Permanent Tooth Damage, Increased Tooth Fragility

4. **Endocrine Disruption & Thyroid Dysfunction**: Fluoride Impairs Thyroid Function: increased risk of hypothyroidism in both pregnant mothers and infants leading to developmental delays, metabolic issues, and cognitive problems. Hormonal Imbalances affect sleep cycles and brain function.

5. **Immune System & Nutrient Absorption Issues**

25 minutes

Impact of fluorosis on the community

Objective: Consider the different ways in which communities are affected by fluorosis.

Graffiti wall activity

1. Post 5 flip charts around the training space. Each flip chart contains a heading. Ask participants to move around the room and write ideas of how the community is impacted in each category. This is an independent activity, so participants can move freely between categories.

   Headings include:

   - **Economic Burden** (e.g. less employable, lower paying work, medical bills)
   - **Lack of opportunity** (e.g. cognitive deficits, physical barriers to work, limited mobility)
   - **Social Stigma** (e.g. isolation and ostracizing of families with affected members, difficult to find marriage opportunities)
   - **Strain on medical system** (e.g. not enough doctors to treat, not enough knowledge of treatment and prevention techniques)
   - **Resource access** (e.g. limited community infrastructure for people with disabilities, limited opportunity for disabled children to get education)

2. Discuss in a larger group:
    - What were the most common themes or points that came up?
    - How can we address these challenges at the community level?

> **Trainer's Note:**
>
> Connect with the larger issue emphasizing on **fluorosis**, how it does not just impact the individual but has a broader **social** and **economic** consequences that affect the entire community.

20 minutes

Prioritizing water-related health concerns

Objective: To develop a framework for prioritizing health concerns related to water contamination.

1. Ask participants the following:
    - We know that fluorosis can have a big impact on individuals and communities, but there are many issues (beside fluoride) with contaminated water. How do we decide what is a priority when it comes to water-related illness?
    - Possible answers include:
        i. Vulnerability: *How many people are affected or at risk?*
        ii. Exposure time: *How long is the community exposed to the contaminant?*
        iii. Severity of consequences: *How serious are the health impacts?*
2. Define different terms for characterizing the impact of different water-related illnesses:
    - **Vulnerability to health effects:** The percentage of the population vulnerable to becoming sick due to exposure (children, elderly).
    - **Exposure:** The level of contact or frequency with the contaminant (e.g., daily consumption of contaminated water).
    - **Health Severity:** The range of health conditions the contaminant causes, from mild discomfort to life-threatening diseases.
    - **Occurrence:** How common is the contaminant in the community (e.g., widespread or local issue)
    - **Social-economic Impact:** The wider effects on social and economic structures (e.g., health care system cost or impact of daily wage)
    - **Persistence:** How long the contaminant remains in the environment or human body after exposure.
    - **Intervention Feasibility:** Can you prevent exposure to the contaminant through intervention?
    - **Treatment Options:** Are there any effective treatment options for the health impacts caused by the contaminant?

- **Time-lag:** How long does it take for the health effect to become evident after exposure?

3. **Activity**:
    - Split the participants into four groups
    - Give each group a **"Community Health Prioritization Table"** and ask them to evaluate the impact of different contaminants present in the communities you work for.
    - For each category, the group should rate as **low**, **medium,** and **high**
    - Ask one group to present the findings. Other groups should listen and then comment or ask questions regarding their rankings.
    - After the presentation, facilitate the discussion on:
        i. Do any of the contaminants rank similarly across groups?
        ii. What are the implications of these rankings?

10 minutes

Review

1. Pair share: Do you think fluoride has had a significant impact on the communities where you live and work?

Resources:

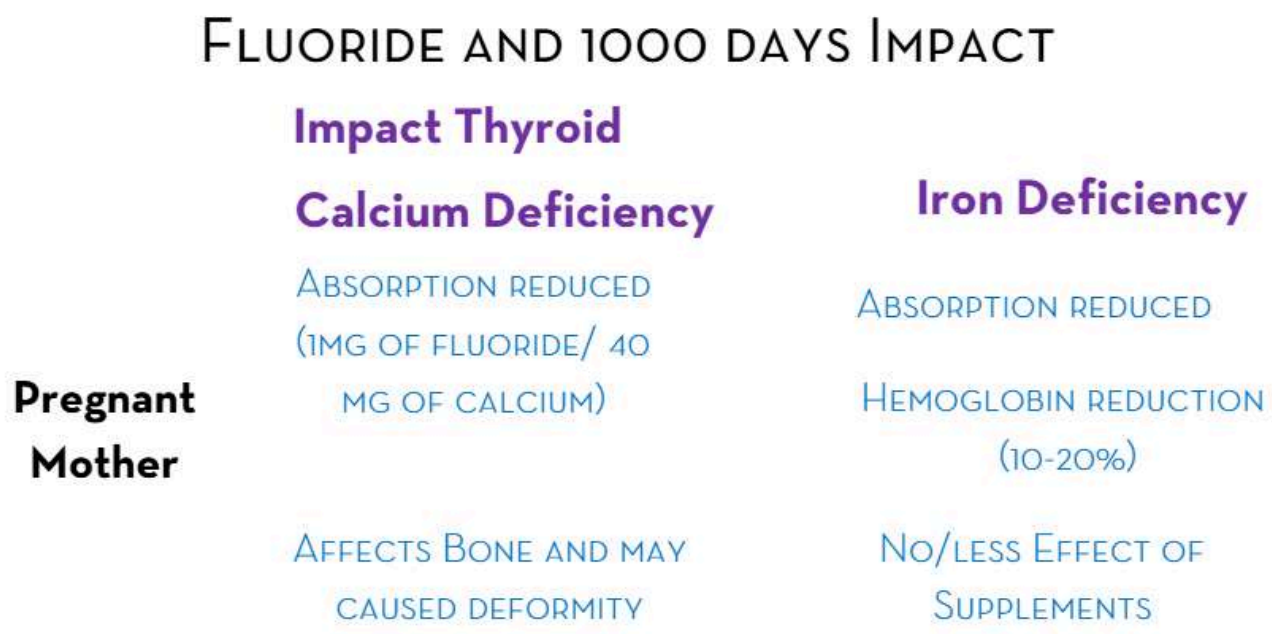
Scenario

1000 Days Impact Scenario

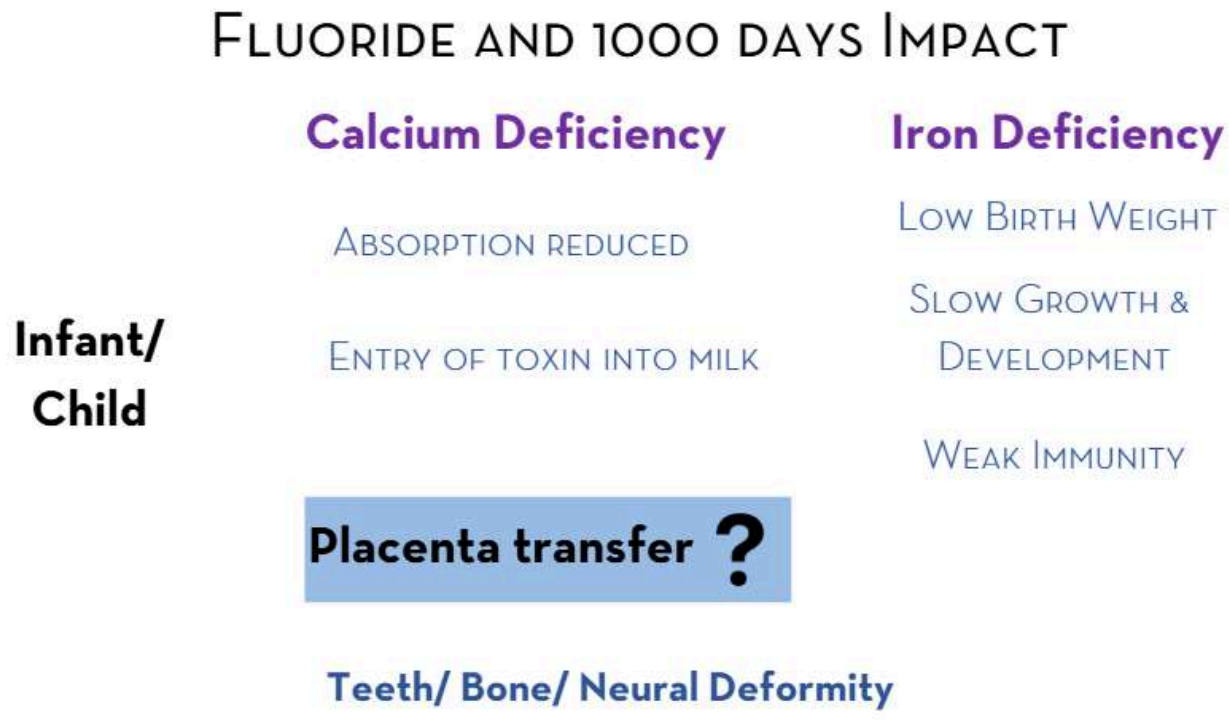
Kunti, a 22 year old living in a rural area is pregnant with her first child. As her pregnancy progresses, she begins to feel unusual symptoms, such as joint pain and fatigue, which she attributes to the normal strains of pregnancy. After nine months she delivers a baby named Arjun. Since she is breastfeeding him, she is often extra thirsty and drinks lots of water. After some time, she realizes his growth is different from some of the other children. By the time Arjun is two years old, it becomes apparent that his growth is delayed, and he has developed some physical deformities in his legs.

Kunti consults a nearby health care worker, Radha, who suggests that the growth delays and deformities are due to fluoride, which she has been drinking in the water. Radha explains that Kunti and her family live in an area with high fluoride levels, and the dangers of fluoride exposure can impact children and adults. She highlights that fluoride impacts developing fetuses and young children more than adults. Radha recommends that Kunti immediately begin treatment for Arjun to give him better opportunities for a healthy future. Radha also recommends additional precautions to prevent the same thing from happening if she has more children.

Slide 1



Slide 2:



Community Health Prioritization Exercise- Facilitator sheet

Contaminant	Type of health impact	Vulnerability to health effects	Exposure	Health Severity	Social - Economic Impact	Persistence	Pace of Impact	Preventing exposure	Health Treatment Options	Urgency to Deal the contaminant
Iron	Liver damage	Low	HIGH	Low	low	Medium	SLOW	easy	Easy	LOW
Typhoid Pathogen	Typhoid	HIGH	High	HIGH	medium	low	FAST	easy	medium	HIGHEST
Fluoride	Fluorosis	HIGH	HIGH	medium-high	HIGH	HIGH	SLOW	difficult	difficult	High
Nitrate	Blue Baby	Medium	low	High	low	low	Medium	difficult	difficult	LOW
Hardness	Eczema	low	HIGH	low	low	high	SLOW	difficult	easy	LOW
Fecal Contamination	Diarrhea	HIGH	HIGH	medium	MEDIUM	LOW	FAST	EASY	EASY	MEDIUM

70 minutes total

Lesson Plan

Fluoride: Water Testing

Lesson Purpose

To help participants understand the different methods of testing fluoride concentration in water and enable them to perform and interpret the results

Learning Outcomes

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

1. Understand the objectives of water testing for fluoride.
2. Discuss and select the appropriate method for fluoride testing.
3. Demonstrate the field testing kit method for fluoride.
4. Interpret and analyze the fluoride test results.

Materials

- Whiteboard/flipchart
- Fluoride Field testing kit (FTK)
- Fluoride sample water
- Printed test kit technical brief
- Three types of testing equipment (or printed photos)
- Printed situation/test selection tables
- Test instructions
- Dilution and calculation instructions
- Interpretation guide
- Fluoride prevalence contour map

Preparation

- Write learning outcomes on flipchart paper
- Prepare three stations for fluoride testing methods:
    - Field Testing Kit (FTK)
    - Ion Selective Electrode (ISE)
    - Spectrophotometer
- Prepare water samples for fluoride testing
- Print technical briefs for each testing method
- Print situation and test selection tables
- Print fluoride prevalence contour map

10 minutes

Introduction

Objective: Engage participants and introduce the concept of fluoride water testing.

1. Show fluoride prevalence contour map introduced in Fluoride Source, Prevalence and Benchmarking Lesson Plan (attached in the *last part*).
2. Ask participants
    - Where are fluoride endemic areas
    - We have tools like this map, **why do you think testing water for fluoride is important**?
3. Share their thoughts by writing key points on a flip chart paper.
4. Review list and explain there are many objectives of testing fluoride in water and add any of the following that were missed:
    - Identifying the source with lowest concentrations
    - Complying with the regulatory standards
    - Sensitizing and building awareness in the community
    - Choosing the appropriate water treatment technology
    - Assessing the effectiveness of water treatment technology
    - Monitoring seasonal variations
    - Recording historical data
    - Monitoring environmental health (plant and animal impacts)
    - Relating concentration with symptoms
5. Ask participants which of the objectives would be beneficial in their work? Why would They want to test in the communities where they work?

20 minutes

Fluoride Testing Methods

Objective: Discuss various methods of fluoride testing and help participants to choose appropriate methods based on their needs.

1. Ask participants to call out if anyone has conducted the water testing before, including the purpose and types of tests used?
2. Split participants into three groups, ensuring those with water testing experience are distributed evenly.
3. Set up three stations for fluoride testing methods:
    - Field Testing Kit (FTK)
    - Ion Selective Electrode (ISE)

- Spectrophotometer

4. At each station, after groups have gone through the factsheets of the testing methods, they will complete the following table for appropriate testing methods for a given situation.

Situation	Appropriate Testing Method(s)
1. Community Sensitization	
2. Selecting safe source	
3. Fluoride removal technology testing	
4. Mapping	
5. Advocacy with the Water Supply Department	

5. After participants visiting all three stations and completing the table, show the powerpoint slide summarizing key point about each method:
    - Field testing kit (FTK): convenient and easy to use.
    - Ion Selective Electrode (ISE): High precision Accurate results but requires technical expertise, costly equipment, and consumables required.
    - Spectrophotometer: Accurate but is expensive equipment.
6. Discuss the outcomes from the completed table, encouraging groups to share their insights on which methods are most appropriate.

35 minutes

Use of Field Testing Kits

Objective: Demonstrate the testing through a field testing kit and guide them through the testing process.

1. Ask participants to discuss the correct way to collect water samples for testing.
2. Explain that fluoride is reactive with silicon-containing compounds, like glass. Use plastic bottles instead of glass to avoid any interference.
3. Emphasize the importance of avoiding contamination during the collection process.
    - Take a water sample
    - Rinse the test tube twice with the water sample. Demonstrate the correct way to collect water samples for testing.
4. Complete a sample testing demonstration.
    - Emphasize personal safety by encouraging the use of gloves and avoiding direct contact with the chemicals
    - Demonstrate the use of a fluoride field test kit (e.g., Ltek fluoride test kit)

i. Add 4 ml of water sample to the test tube
ii. Add 1 ml of the test reagent to the test tube
iii. Wait for colour change to occur

5. Demonstrate how to view and interpret colours of the samples correctly.

- Use white paper or a background to observe the colour change.
- Ensure proper lighting for accurate readings.
- Compare the solution colour with a colour chart.
- Ask them to observe the colour change on the test kit displayed on *Slide 1*:
    i. Pink: Fluoride level is the safe limit (less than 1 PPM)
    ii. Orange: Fluoride level is moderate (1-3 PPM)
    iii. Yellow: Fluoride level is unsafe (3 PPM and above)
- Take a sample of high fluoride concentration to show color change to yellow.
- Explain that for sensitization, FTK is a great visual tool to help community members see the connection between their symptoms/health risk and water quality.

6. Provide an opportunity for hands-on practice.

- Divide participants into small groups (suggest pairs if enough kits are available) and provide each group with a fluoride test kit and printed instructions (or display on ppt).
- Walk around to guide and support each group, ensuring that every participant gets hands-on experience in performing the test correctly.

7. Demonstrate the dilution method (**optional**).

- Ask participants, “If you are trying to select the best water source among options with high fluoride levels, how could you determine which is best?”
    i. This is relevant when you need to determine a more accurate concentration range than *above 3 PPM*.
- Explain that to determine a more accurate concentration, they can use the dilution method.
- Demonstrate dilution, re-testing, and interpretation:
    i. Take a water sample showing high fluoride levels
    ii. Add a known volume of distilled water to dilute the sample
    iii. Show how to re-test the diluted sample using the field testing kit
    iv. Interpret the results based on the color change observed
- Demonstrate how to calculate concentration in a diluted sample.
    i. Original concentration = Measured concentration * dilution factor
    ii. Explain the dilution factor (for example if you diluted 1 ml of sample water in 4 ml of distilled water, the dilution factor is 5)

8. Provide an opportunity for hands-on dilution practice (**optional**).
    - In the same groups, participants will dilute their samples, re-test, and interpret the results.
    - Provide each group a dilution instruction sheet that includes a simple equation to calculate the concentration.
    - Walk around to guide and support each group, ensuring every participant gains hands-on experience in performing the dilution and test correctly.
    - Encourage groups to compare their result with standard fluoride concentration levels provided by BIS guidelines

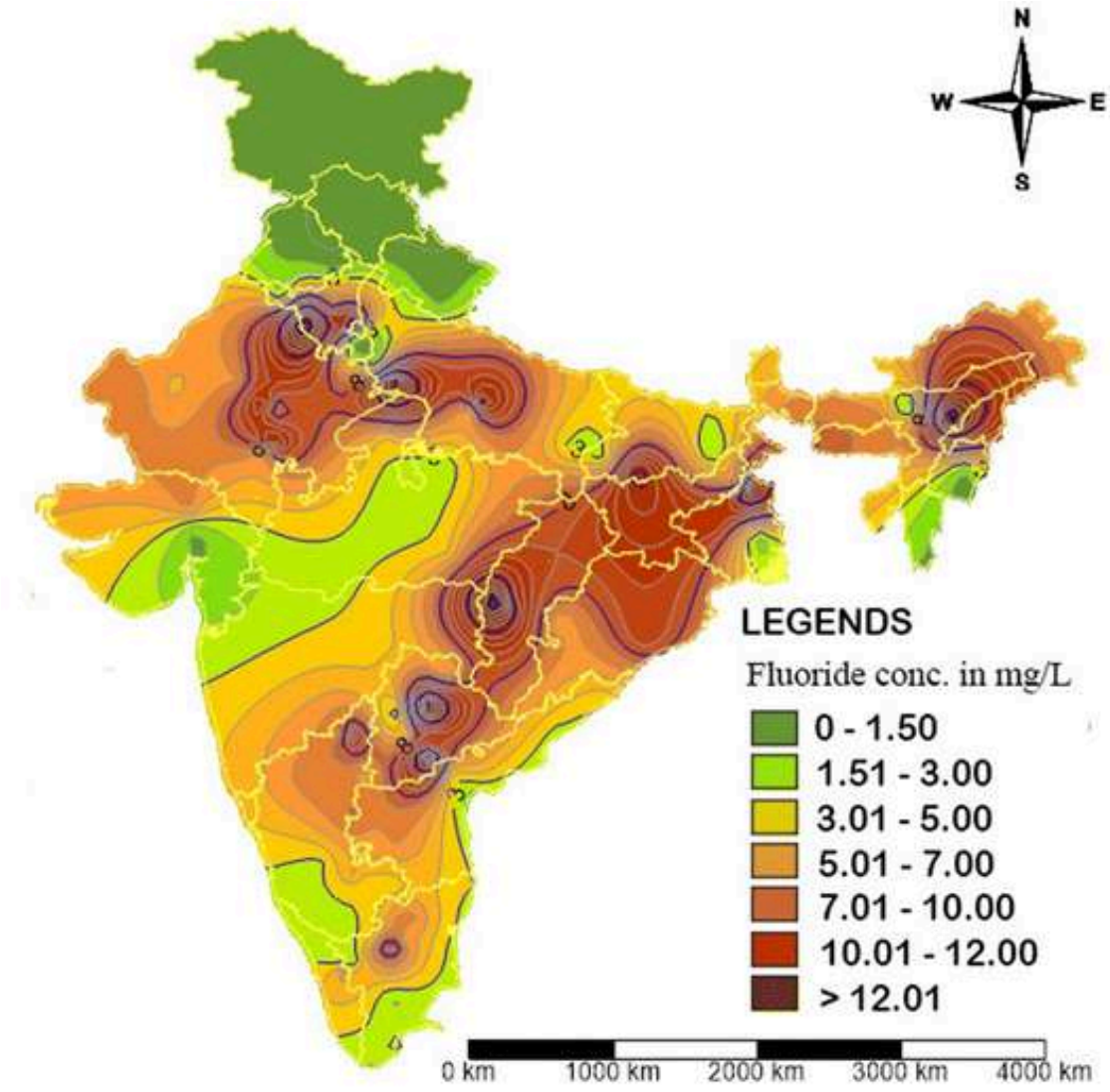
5 minutes

Review

1. Ask participants to reflect on the testing process and share their thoughts on how confident they feel about performing fluoride tests independently.

Resources:

Fluoride prevalence contour map



Technical Brief: Field Test Kit (LTEK) for Fluoride Testing in the Field

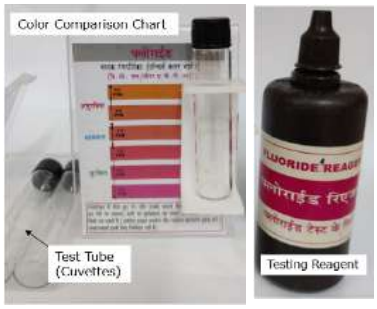
Overview:

The **Field Test Kit (LTEK)** for fluoride typically uses colorimetric methods to detect and quantify fluoride levels, offering quick, real-time results without the need for complex laboratory equipment.

This kit is designed to provide an accurate, portable, and efficient solution for testing fluoride concentrations in water in remote or field settings. It allows field personnel to assess water quality, especially in areas where high fluoride levels can pose health risks, such as dental and skeletal fluorosis.

Key Components of the LTEK:

1. **Reagents:** The kit includes the necessary chemical reagent which reacts with fluoride ions to produce a measurable colour change.
2. **Colour Comparator/Visual Scale:** The intensity of the colour change compared to a reference chart to determine the fluoride concentration.
3. **Cuvettes and Vials:** Used to hold the water samples for analysis.
4. **Syringes and Pipettes:** For accurate measurement and transfer of water samples and reagents.



is

Testing Procedure:

1. **Sample Collection:** A water sample (4ml) is collected in a clean container or cuvette.
2. **Reagent Addition:** Fluoride-specific reagent is added (1ml) to the water sample. Typically, these reagents react with fluoride ions to form a coloured complex.
3. **Colour Development:** After adding the reagents, allow the sample to sit for a few minutes for the colour to develop.
4. **Measurement:** Compare the developed colour with a colour chart (for visual testing).
5. **Result Interpretation:** Based on the colour, the fluoride concentration in the water sample can be determined.

Advantages of LTEK:

- **Portability:** Designed for field use, the kit is compact and easy to transport.
- **Ease of Use:** Requires minimal technical training and can be used by personnel with basic knowledge of water quality testing.
- **Cost-Effective:** LTEK kits are affordable, especially in low-resource settings.
- **Quick Results:** Provides immediate data for decision-making, enabling real-time monitoring and intervention.

Limitations:

- **Sensitivity:** Some kits may not detect very low concentrations of fluoride accurately.
- **Interferences:** High levels of other ions, such as chloride or sulphate, can interfere with the test results.

- **Accuracy:** While the kit is useful for on-site testing, it may not be as accurate as laboratory methods, especially for very precise or regulatory purposes.
- **Reagent Life:** The reagents may degrade over time or require specific storage conditions, such as being kept in a cool, dry place.

Maintenance and Care:

- **Proper Storage:** Ensure that the reagent and other components are stored correctly, especially when in the field.
- **Sample Handling:** Avoid contamination of samples or cuvettes to ensure reliable results.

Applications:

- **Drinking Water Testing:** Used to assess fluoride levels in potable water sources, particularly in areas prone to natural fluoride contamination.
- **Monitoring:** Deployed in field surveys for fluoride contamination in both rural and urban settings.
- **Emergency Water Testing:** Suitable for use in emergency situations where immediate water quality assessments are required.

Technical Brief: Ion-Selective Electrode (ISE) for Fluoride Measurement

Overview:

The **Ion-Selective Electrode (ISE)** is a powerful tool for measuring the concentration of specific ions, such as **fluoride**, in aqueous solutions. It operates by detecting the ion activity in a solution through a selective membrane, which is designed to respond only to fluoride ions (F^-). The ISE for fluoride is commonly used in water quality monitoring, and blood and urine samples to detect fluorosis.

Sample Preparation:

To ensure accurate results, sample preparation is essential:

- **Buffering**: Fluoride ISE measurements are pH-dependent, so **total ionic strength adjustment buffer (TISAB)** is added to the sample. TISAB maintains a constant ionic strength and prevents interference from hydroxide ions, which can affect fluoride readings at higher pH levels.
    - **Ratio of sample and Buffer solution (TISAB III): 10:1**
    - **5 ml raw water sample and 0.5 ml (TISAB III):**

- **Interference Control**: Other ions, such as hydroxide (OH^-) and aluminium (Al^{3+}), can interfere with the measurement by either mimicking fluoride or forming complexes with it. TISAB also helps in controlling these interferences.

Key Applications:

1. **Drinking Water Analysis**: Monitoring fluoride levels to ensure they fall within recommended limits (e.g., **0.7 to 1.2 mg/L** in drinking water, as per WHO guidelines and **1 to 1.5 mg/L** BIS standards).
2. **Urine and blood sample**: To assess blood and urine samples to detect fluorosis.

Advantages:

- **Selective**: Highly selective for fluoride ions, providing precise measurements.
- **Rapid**: Offers fast response times, making it suitable for real-time monitoring.
- **Simple Sample Preparation**: Does not require complex sample handling, apart from buffering.
- **Cost-Effective**: Compared to more advanced spectroscopic methods, ISE is relatively affordable.
    - Costs approximately consumables INR 25 each sample
    - Capital costs: Electrode and meter – INR 200,000 Each set

Limitations:

- **Interference**: While the ISE is selective, certain ions (e.g., OH^-) at high pH can interfere with measurements.
- **Calibration Sensitivity**: The electrode must be regularly calibrated with fluoride standards to maintain accuracy.
- **Temperature Dependence**: Fluoride ISE response can vary with temperature, so temperature compensation is necessary for precise results.

Maintenance and Care:

- **Storage**: The ISE should be stored in fluoride solution (1 PPM) when not in use to prevent drying out the membrane.
- **Cleaning**: Regular cleaning with distilled water can help maintain electrode performance.

Technical Brief: Fluoride Analysis By Spectrophotometer

Overview:

The Spectrophotometer is a reliable, high-precision designed for measuring various water quality parameters, including **fluoride concentration**. The device is used in conjunction with specific reagents and methods to detect fluoride ions in water samples through colorimetric analysis. Spectrophotometers like the **PTW 10005** operate by measuring the intensity of light absorbed by a sample at a particular wavelength.

Fluoride Analysis:

To ensure accurate results, sample preparation is essential:

For fluoride analysis, the **SPADNS method** is widely adopted. Fluoride ions in the sample react with a zirconium-SPADNS reagent, producing a decrease in the intensity of the coloured complex, which is detected by the spectrophotometer. The Spectrophotometer can measure this colour change, allowing for accurate determination of fluoride concentration in the sample.

Steps for Fluoride Testing:

1. **Sample Preparation**: Collect the water sample and prepare the SPADNS reagent according to the method guidelines.
2. **Reaction**: Add the SPADNS reagent to the sample. Fluoride ions will interact with the zirconium-dye complex, leading to a decrease in colour intensity.
3. **Measurement**: Using the Spectrophotometer, measure the absorbance .
4. **Interpretation**: The absorbance values are compared to a standard curve to quantify fluoride concentration.

Key Applications:

- **Water Quality Monitoring:** The PTW 10005 is frequently used in monitoring fluoride levels in drinking water to ensure compliance with **WHO guidelines and BIS standards** (e.g., **0.7 to 1.2 mg/L** and **1 to 1.5 mg/L** respectively).
- **Environmental Testing:** It is also used to detect fluoride contamination in natural water bodies, especially in areas where fluoride is naturally occurring at high levels.
- **Industrial Applications:** Spectrophotometer is useful in industrial water testing, particularly in sectors where fluoride might be a by-product, such as in aluminium production.

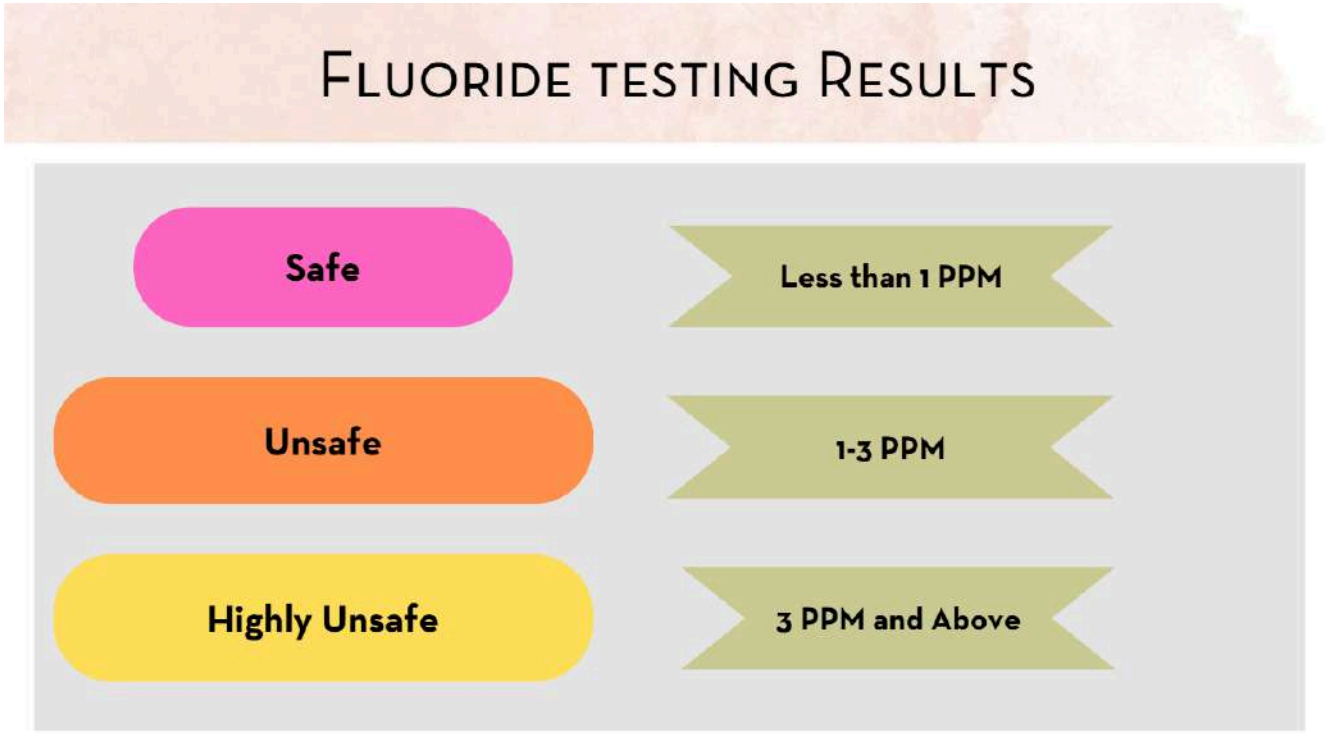
Advantages of the PTW 10005:

- **Accurate and Reliable**: Provides precise fluoride concentration readings with minimal interference from other ions.
- **Compact Design**: Suitable for both laboratory and field use due to its portability and ease of use.
- **Robust Calibration**: Easily adjustable for various fluoride concentration ranges, ensuring reliable data collection.

Limitations:

1. **Limited Detection Range**: The Spectrophotometer may have difficulty accurately measuring very low or very high concentrations of fluoride, especially if the concentration falls outside its optimal detection range.
2. **Interference from Other Ions**: Certain ions present in water, such as chloride, sulphate, or phosphate, can interfere with fluoride detection using the SPADNS method. These ions may alter the colour development, leading to inaccurate results.
3. **Dependence on Sample Preparation**: Accurate fluoride detection with the Spectrophotometer relies heavily on precise sample preparation and reagent handling. Variations in preparation can cause inconsistent readings.
4. **Single Wavelength Limitation**: Although the device supports multiple wavelengths, specific tests like fluoride detection using the SPADNS method are limited to a fixed wavelength (around 570 nm). This narrow focus may limit its versatility for other colorimetric tests.
5. **Reagent Stability**: The SPADNS reagent used for fluoride testing can degrade over time or under certain storage conditions, which might lead to inaccurate measurements if not handled properly.
6. **Field Use Limitation**: While portable, Spectrophotometer is still better suited for controlled laboratory environments. Field use may be less practical due to environmental factors like temperature and humidity that can affect the accuracy of the readings.

Slide 1: Water testing results from field testing kit



90 minutes total

Lesson Plan

Reducing Ingestion of Fluoride in Water

Lesson Purpose

To make participants aware of reducing ingestion of fluoride and different defluoridation techniques available for reducing fluoride concentration in drinking water.

Learning Outcomes

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

1. List ways of reducing ingestion of fluoride through water including dilution, alternative water sources and defluoridation.
2. Assess the advantages and limitations of various defluoridation techniques.
3. Identify appropriate strategies for reducing fluoride ingestion in a specific context.

Materials

- Whiteboard/flipchart
- Marker
- Sticky note
- Fact sheets on defluoridation techniques

Preparation

- Write learning outcomes on flipchart paper
- Prepare PowerPoint with four case studies
- Print technical briefs for each defluoridation methods

15 minutes

Introduction

Objective: Introduce participants to various strategies for minimizing fluoride ingestion through water.

1. Present the scenario: "*You've prepared a curry, but you realize that you've added too much salt. The food doesn't taste good, and it's difficult to eat. What will you do to make it good to eat?"*
2. Encourage participants to think about different options they might use to reduce the saltiness:
    - Throw it out and start again
    - Add more ingredients or dilute with water
    - Add peeled potato or dough to absorb the salt
3. Connect these ideas with methods for reducing fluoride ingestion through water:
    1. **Throw it out and start again:** Choose an alternative fluoride-safe source for drinking water (purchased water, rainwater, surface water, alternative fluoride safe groundwater source)
        - Protect fluoride-safe sources from overexploitation and contamination
        - Ensure that alternative sources will not cause other health effects (other contaminants in water, purchased RO – no minerals)
        - Variation of fluoride levels between wells in the same area
    2. **Adding more ingredients or diluting with safe water:** Dilution
        - Source dilution: Recharging groundwater with harvested rainwater to dilute fluoride levels
        - Point of use dilution: Diluting fluoride-contaminated water with water from other sources having no or low fluoride content/harvested rainwater (why would we do this? when other sources are costly or limited, or to improve treatment efficiency)
    3. **Add peeled potato or dough to take out the salt from the curry:** Defluoridation techniques for reducing fluoride concentration like adding a potato, there are ways to reduce the fluoride in water.
        - Ask, "what techniques have you heard of?"
        - Possible answers: RO, Nalgonda (Activated Alumina)
        - Explain we will be learning more about these techniques next.

50 minutes

De-Fluoridation Techniques

Objective: Introduce participants to various defluoridation techniques through discussion and factsheets.

Station Work: De-Fluoridation Options

1. Set up four stations for different Defluoridation methods.
    - Dr. Robin Dutta's limestone method
    - Activated alumina filter (CAWST WASH resources)
    - Bone char filter (CAWST WASH resources)
    - Reverse Osmosis (RO)
2. At the stations provide: Technical Brief, media sample, images and flipchart paper with advantages and limitations as title.
3. Divide participants into four groups. One group will start at each of the four stations. At each station, they should:
    - Read through the Fact Sheet
    - Discuss and add 1-2 advantages or limitations for each method and write on the flip chart paper
    - Each group will spend around 5 minutes at one station and move to another
4. After all the groups have rotated through all the stations, ask the participants to return to their original station.
5. Ask each group to summarize to the rest of the group key advantages and key limitations for the method at their station. Discuss as a full group and correct or add to their points as needed.
6. Lead discussion around acceptability and best practices when introducing new technologies in a community:
    - Trial/pilot
    - Give options
    - Consider the supply chain
    - Affordability and availability
    - Maintenance requirements
    - Sustainability

20 minutes

Selecting Appropriate Techniques

Objective: Participants identify possible techniques to reduce fluoride ingestion through water that could be appropriate and acceptable for the communities they work for.

1. In the same 4 groups, hand out the **Fluoride Reduction Technique comparison table** to each group.
2. Ask the participants to develop a hypothetical scenario of the community struggling with fluorosis. Scenarios should include information such as:
    - Location
    - Economic status
    - Concentration of fluoride contamination
    - Cultural preferences
    - Rainfall information
3. The group will fill out the table based on a hypothetical scenario they developed.

5 minutes

Review

1. Display the 4 case studies on PPT/ handout and ask participants to identify which solutions would be good to pilot and offer to community members.
2. Write down their thoughts in their notebooks.
3. Groups will present the scenario and their selected solution.

Resources:

Technical Brief 1

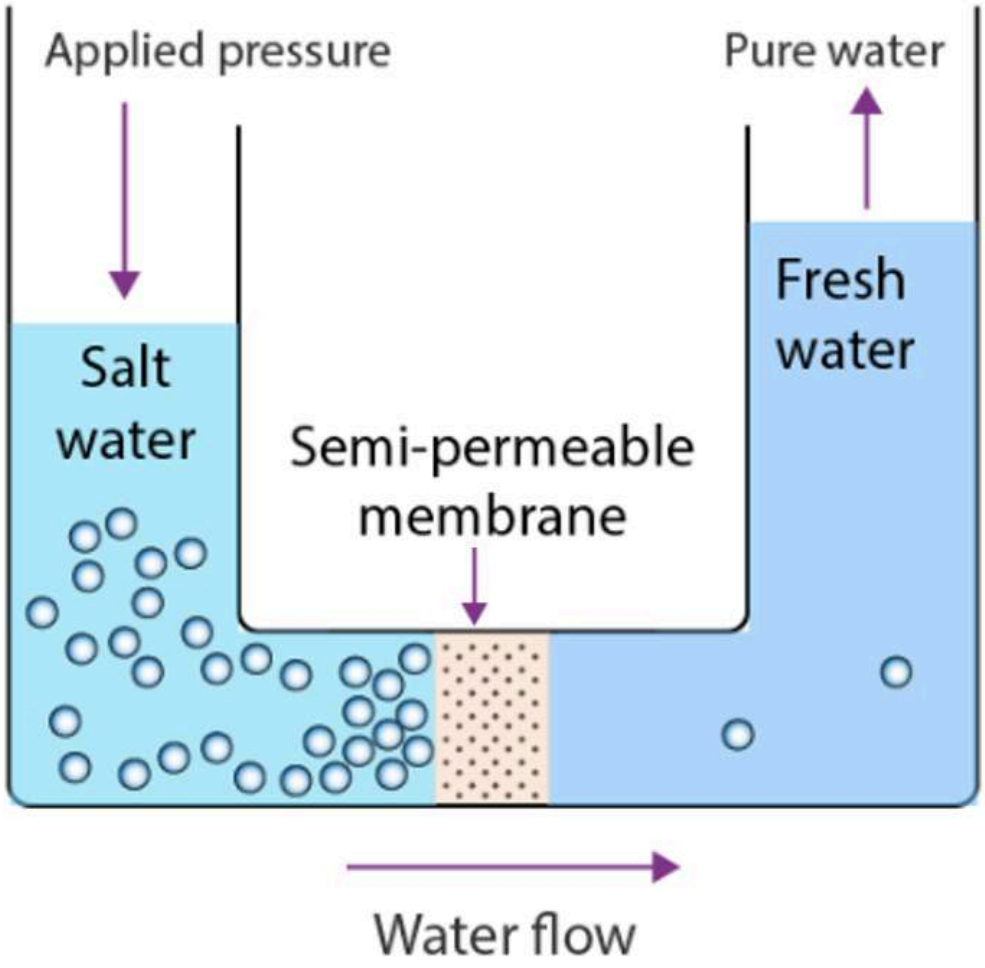
Fluoride Removal from drinking water through Reverse Osmosis (RO) System

Reverse osmosis (RO) is a membrane treatment process primarily used to separate dissolved matter from water. RO is most commonly known for its use in drinking water purification, particularly with regard to removing salt and other impurities present in water.

How does it work?

When the solution side of the semi-permeable membrane is subjected to a pressure, the water molecules in the solution side move through the semipermeable membrane to the other side leaving behind the larger molecules (impurities). Thus the pure water is collected with no or very little impurity.

Fluoride is also removed from the water.



Disinfection

It is recommended to disinfect the filtered water to eliminate the risk of microbial contaminants. that may still be present. Most RO systems commercially available use UV disinfection methods.

Advantages of Reverse Osmosis

- This process can be used effectively to remove many types of dissolved and suspended particles from the water. Almost all other materials are rejected by the RO and filtered water approaches distilled water in quality.
- It is used in desalinating seawater.
- Available units are relatively compact and require little space
- In average use, the membrane has a life of a little more than one to two years, before that replacement is necessary.
- Periodic complete sterilization of the RO system with formalin or other sterilant is practical.

Disadvantages of Reverse Osmosis

- Cellulose acetate membranes have limited pH tolerance. They degrade at temperatures greater than 35^{o}C. They are vulnerable to bacteria.
- Polyamide membranes are intolerant of temperatures but have poor tolerance for free chlorine.
- significantly reduce the good minerals like calcium and magnesium also. In the long term it may cause tiredness, muscle cramps, general weakness, hyperacidity and cardiovascular disorders in severe cases.
- Installation and maintenance costs are high.
- Needs electricity to run the system.
- Water wastage is very high. The wastewater produced contains a high level of impurities which is an environmental burden in the long term.

Technical Brief 2

Fluoride Removal from drinking water through limestone and Phosphoric Acid (PA)

This Technology of Fluoride removal named 'Fluoride Nilogon' was developed by Prof. Robin Dutta, Tezpur University. We thank him for sharing it for a social cause.

How does it work?

- This process relies on precipitation and adsorption.
- The method involves using a bed of crushed limestone (4 - 12 mm size), where fluoride containing water, pre-mixed with a small amount of edible PA, is allowed to react for 3 hours to remove fluoride and then filtered.
- A bed of crushed limestone remains effective for many years.

The filtration method works in batch mode in a two-stage process:

- Stage 1: Fluoride removal
- Stage 2: Filtration

Preparing Limestone bed

1. Take the required quantity of crushed limestone grit of 1 to 15 mm size. Wash it with water and place it in a bucket (40 litre size bucket is appropriate for household scale) fitted with a tap.
2. Preparing diluted PA: Add 10 ml of Phosphoric Acid (85% PA solution available in market) in distilled water to make it 1L solution.
3. Limestone bed activation is a one time process before carried out it is used for fluoride removal, as follows
    a) Add 137 ml of prepared diluted PA solution in 20L of fluoride containing raw water.
    b) Fill the limestone bed bucket (reactor) with the raw water prepared in step a) up to the top of the limestone bed, and let it sit for 3 hours.
    c) After 3 hours, filter the water through the appropriate filter and test the filtrate for fluoride concentration.
    d) Repeat the process until the fluoride concentration in the filtrate drops below 0.1 ppm. This step may need to be repeated one, two, or more times.
    e) Once the fluoride concentration in the filtrate is below 0.1 ppm, the reactor is considered ready for use.

De-fluoridation treatment

Stage 1: Fluoride removal

For fluoride removal add diluted PA solution (0.5ml of per litre) in raw water before pouring into n the activated limestone reactor. e.g. for a 15 litre raw water, the amount diluted PA solution to be added is 7.5 ml and let it sit for 3 hours in the limestone bed.

Stage 2: Filtration

After 3hrs of raw water (mixed with diluted PA solution) sitting in limestone bed, is filtered to remove any suspended particles through a filter (Bio-sand filter/ceramic pot filter/ hollow fiber membrane filter)

Appropriate filtration methods can be selected based on the available resources, availability and specific water treatment requirements. Options include:

Bio-Sand Filter (JalKalp): A Bio-Sand filter uses layers of sand, gravel, and it forms a biolayer to filter out contaminants which is effective for removing suspended solids, microbiological, and some chemical contaminants like iron, manganese and can also be adapted for arsenic.

Ceramic Pot Filter: A Ceramic Pot Filter consists of a silver impregnated ceramic pot with small pores and micro channels that trap suspended particles, microbiological and chemical contaminants (iron, manganese and arsenic).

Hollow Fiber Filter: A Hollow Fiber filter uses a bundle of porous, straw-like tubes to filter out different physical impurities of size bigger than the pore size.

Disinfection

It is recommended to disinfect the filtered water to eliminate the risk of microbial contaminants. that may still be present. Any disinfection method (chlorine, boiling the water, or employing Solar Water Disinfection (SODIS)) which is suitable as per the availability and acceptability can be adopted.

Advantage and Disadvantage

This is very user-friendly low-cost technology, and works with a large range of fluoride concentrations. Its limitation is arranging limestone chips of appropriate size if limestone is not available locally.

Note:

- Limestone quality may vary from source to source so it is better to conduct trials before using.
- The size of limestone grit can be in the range of 0.4 to 1.2 cm. It is not necessary to have a particular size of grit. Particles of size smaller than 4 mm may lead to clogging of water flow. Larger particle size will reduce the limestone surface area and hence reduce the effectiveness of the limestone. While putting the limestone grit in the reactor, the larger particles may be put in first in the lower side and the mix of smaller bigger size chips may be put in the upper side. The very small size chips may be rejected by sieving.
- Important: This brief is developed just to create awareness about the technology, we recommend connecting with Dr Robin Datta, Tezpur University for further details needed for adoption.

Technical brief 3

Activated alumina filter

Potential Treatment Capacity

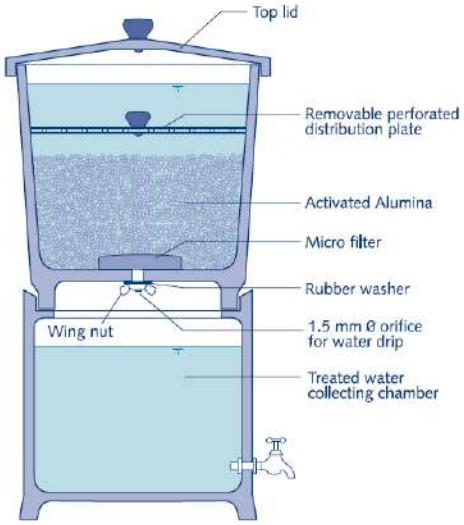
Very Effective For:	Somewhat Effective For:	Not Effective For:
· Fluoride · Arsenic · Turbidity · Taste, odour, colour		· Bacteria · Viruses · Protozoa · Helminths · Hardness

What Is Activated Alumina Filter?

Activated alumina, also called aluminium oxide (Al_2O_3) granular, is one of the most widely used materials for the removal of chemicals from water. This highly porous material is prepared by low temperature (300-600°C) dehydration of aluminium hydroxides. Activated alumina grains are packed in a filter like sand. When water passes through it, certain contaminants in the water adsorb (stick) to the activated alumina. Activated alumina removes fluoride from water, and can also be used for arsenic removal (see the corresponding Arsenic Removal by Adsorption factsheet).

How Does It Remove Contamination?

Fluoride is removed from water through an exchange reaction at the surface of the activated alumina. Fluoride adsorbs to the alumina more easily than other molecules in water. This results in high defluoridation capacity. According to laboratory tests, the fluoride removal capacity of alumina is between 4 and 15mg of fluoride per gram alumina (Hao and Huang, 1986). However, field experience shows that the removal capacity is often about 1mg/g (COWI, 1998). The treatment capacity also depends on the specific grade (quality) of activated alumina, the particle size and the water chemistry (pH, alkalinity and fluoride concentrations). The optimum dosage of activated alumina for a particular source water needs to be determined by conducting a jar test experiment.



Activated Alumina-based Household Defluoridation (Credit: Lyengar, 2002)

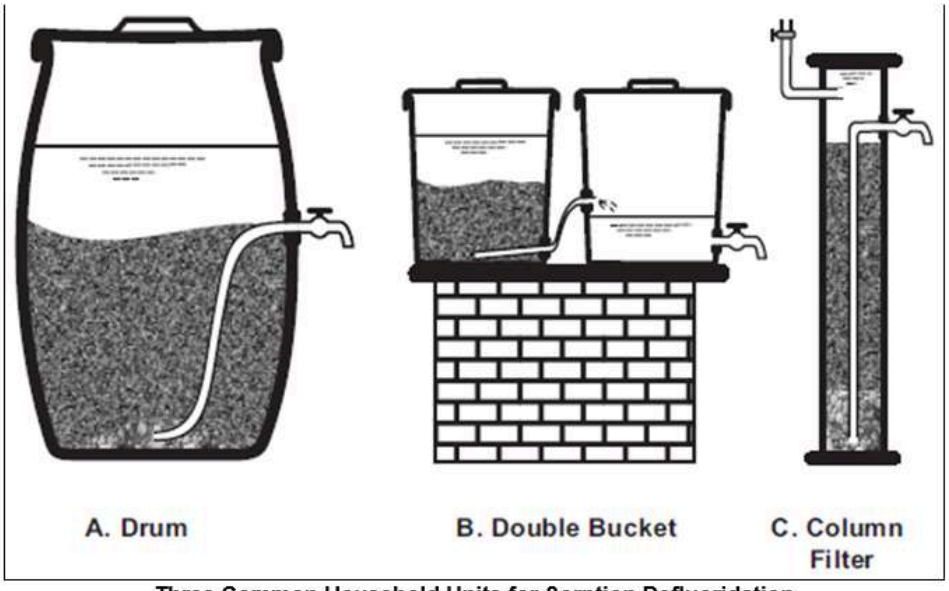
Operation

There are different kinds of activated alumina filters. One of them consists of two containers (see above diagram). The upper container holds the activated alumina (3 kg, depth of 17 cm, Lyengar 2002). The top of this container can be covered with a perforated stainless steel disc to avoid disturbing the media when water is poured in. It should also be covered by a lid. The lower container can be any kind of bucket or pot with a tap, used for storing the treated water.

Activated alumina filters can also consist of a domestic candle water filter with an additional middle chamber holding a bag of activated alumina. The filter could also simply be a bucket, drum or column with

a tap and drainage pipe that is filled with activated alumina (see illustration below). The contact time of the filter is the amount of time the fluoride contaminated water is in contact with the activated alumina. Bulusu and Nawlakhe (1988) conducted jar test experiments to determine the effect of contact time on fluoride removal. It was observed that the optimum contact time to reduce the fluoride level from 4.8 mg/L to 1 mg/L is 30 minutes. This can be used as a recommendation, but as of yet there is no formal recommendation for contact time.

When the activated alumina media becomes saturated, meaning there are no more places for fluoride to adsorb to the media, the media can be regenerated using HCl, H_2SO_4, alum or NaOH. The wastewater created from this process should be disposed of in an appropriate manner away from water sources and human contact. Note: When 4% caustic soda (NaOH) is used for regeneration it needs to be followed by a neutralization step to remove residual NaOH from the filter.



Three Common Household Units for Sorption Defluoridation (Credit: WHO, 2006)

Inlet Water Criteria

- The pH of the water should preferably be between 5 and 6; at a pH > 7 silicate and hydroxyl ions become stronger competitors against fluoride ions for adsorption preference (Renu, Singh and Maheswari, 2001)

Treatment Efficiency

	Bacteria	**Viruses**	**Protozoa**	**Helminths**	**Turbidity**	**Fluoride**
Laboratory	Not available	Not available	Not available	Not available	Not available	90% in batch[1] up to 98% in column[2]
Field	Not available	Not available	Not available	Not available	Not available	Not available

[1] An initial fluoride concentration of 5 mg/L reduced to down to 1.4 mg/L before regeneration and to 0.5 mg/L on regeneration with 2N HCl (Savinelli, 1958).
[2] (Nakkeeran and Sitaramamurthy, 2007)

Operating Criteria

Flow Rate	Batch Volume	Daily Water Supply
Not available[1]	Not available[1]	Not available[1]

[1] Depending on filter type (WHO, 2006)

- The flow rate, batch volume and daily water supply depend on the kind of filter used

Robustness

- Taps can be broken and may need replacement
- Activated alumina needs to be replaced or regenerated once saturated
- It is necessary to measure the fluoride concentration in the outlet water to know when to replace or regenerate media

Estimated Lifespan

- Media regeneration every 6 months to 1 year
- Estimation of the filter lifespan can be made based on the fluoride concentration of the raw water, the daily volume through the filter and the adsorption capacity of the activated alumina

Manufacturing Requirements

Worldwide Producers:

- Many producers around the world

Local Production:

- Difficult and complex to manufacture, local production is not feasible

Maintenance

- The regeneration cannot be left to the users: skilled labour is required to test the filtered water and recharge activated alumina
- The effluent from regeneration is high in fluoride and must be disposed of carefully to avoid recontamination of nearby groundwater

Direct Cost

Capital Cost	Operating Cost	Replacement Cost
US$35-50[1]	US$0/year	US$1.3-2/kg media[1]

Note: Program, transportation and education costs are not included. Costs will vary depending on location and filter type.
[1] India, WHO 2006

- Activated alumina has become less costly and more easily available, especially in locations near to where it is manufactured.

Technical Brief 4

Bone Char filter

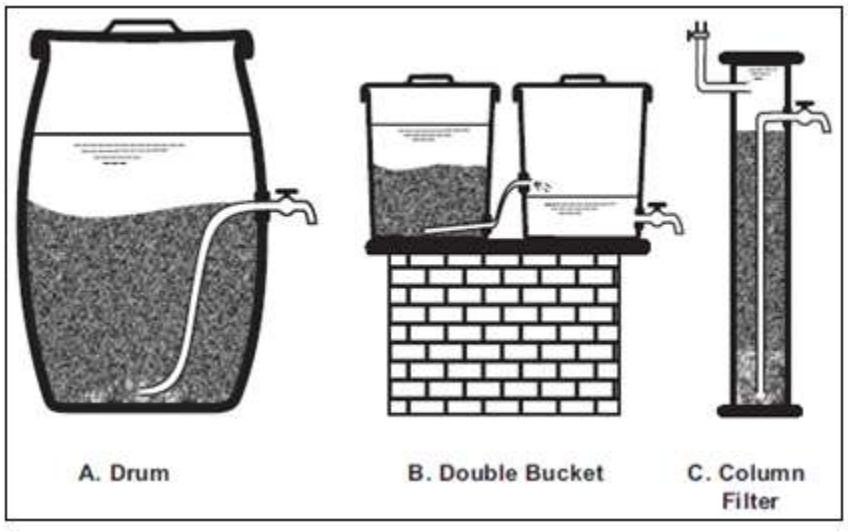
Potential Treatment Capacity

Very Effective For:	Somewhat Effective For:	Not Effective For:
· Fluoride · Taste, odour, colour	· Turbidity · Other Chemicals	· Bacteria · Viruses · Protozoa · Helminths · Hardness

What Is a Bone Char Filter?

Bone was one of the earliest media suggested for fluoride removal from water. It was not widely implemented due to the bad taste of treated water, the high cost and unavailability. But in 1988, the WHO claimed it to be an applicable technology for developing countries.

Bone char is a blackish porous granular media capable of absorbing a range of contaminants. The bone char grains are packed in a filter (bucket, drum or column) and water flows through. Bone char is made from animal bones that are charred (burnt) and crushed. Correct preparation of the bone char is essential to ensure good fluoride removal and to avoid unattractive taste, colour and odour in the treated water. Decades ago, bone char was industrially produced and widely available, but now the supply is limited. However, bone char grains can be produced locally by communities.



Three Common Households Units for Sorption Defluoridation (Credit: WHO, 2006)

How Does It Remove Contamination?

Major components of bone char are calcium phosphate, activated carbon and calcium carbonate. Fluoride is removed from water through a process based on ion exchange. When raw water containing

fluoride comes into contact with bone char, the fluoride ion changes places with the carbonate ion in the bone char, and the fluoride becomes "stuck" to the bone char.

Bone char has high fluoride removal efficiency, and can also absorb a wide range of other contaminants. The fluoride adsorption capacity is 2mg fluoride per gram of bone char (Albertus, 2000).

Operation

Bone Char Production

The steps for preparing bone char are: charring, crushing, sieving and washing/drying.
The colour of the charred bone is a simple way to determine its quality (Jacobsen and Dahi, 1997):

- Grey-brownish: Highest fluoride removal
- Black: Still contains organic impurities causing odour and colour
- White: Reduced fluoride removal capacity

Bone char from any animal needs to be carbonized at a temperature of 400 to 500 ºC with a controlled air supply. Then the charred bones can be crushed manually or by using a crushing machine. Particles between 0.5 mm and 4 mm can be used as media. If bone char is not prepared properly, it may result in low defluoridation capacity and/or lower water quality.

Filter Examples

Bone char media can be use in different kinds of filters. One example is a 20 litre bucket with a tap fixed at the bottom connected to an outlet pipe. A perforated plate can be placed on the surface of the media to avoid disturbance during addition of raw water. The use of bone char alone is efficient with a flowing system, but is not effective in a batch method (Larsen, 1993).

Single and Combined Bone Char Filter (Credit: Eawag, 2006)

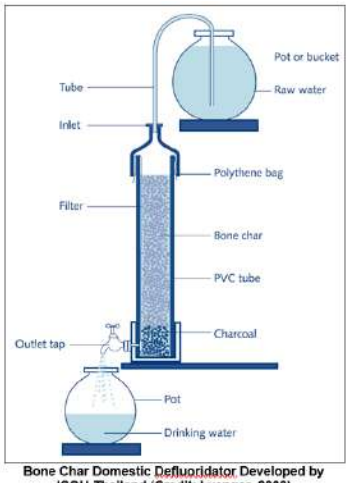
The water level in the filter should never drop below the top of the bone char. If the bone char is left dry, its adsorption capacity will decrease. The water should be in contact with the bone char for a minimum of 20 minutes. The filter can be combined with a ceramic candle to remove microbiological contamination as well (see picture). For new filters or after changing the media, the first few containers of treated water should be discarded due to high turbidity and colour (CDN, 2006).

Media Regeneration

Bone char media needs to be renewed or regenerated periodically. Regeneration can be done using caustic soda (NaOH). The fluoride concentration in the treated water needs to be measured periodically to know when to replace or regenerate the media. However, an estimation of the lifespan of the media can be made based on the fluoride concentration of the source water, the volume of water filtered each day and the adsorption capacity of the bone char.

Acceptance

The use of bones in water treatment might not be consistent with local customs and beliefs. Depending on the community, it may be important to consider the implications of religious beliefs, etc. on acceptance of using bone char for water treatment.



Bone Char Domestic Defluoridator Developed by ICOH-Thailand (Credit: Lyengar, 2002)

Inlet Water Criteria

- No specific limits

Treatment Efficiency

	Bacteria	Viruses	Protozoa	Helminths	Turbidity	Fluoride
Laboratory	Not available	N/A	N/A	N/A	N/A	65% in batch[1] 99% in flowing system[2]
Field	N/A	N/A	N/A	N/A	N/A	90%[3]

[1] Watanesk and Watanesk, 2000

[2] Mavura et al., 2002

[3] CDN, 2006

Operating Criteria

Flow Rate	Batch Volume	Daily Water Supply
Not available	1.6 to 6.5 litres[1]	Not available

1 Depending on filter type (WHO, 2006)

- The flow rate, batch volume and daily water supply depend on the kind of filter used

Robustness

- Taps can be broken and may need replacement
- Bone char needs to be replaced or regenerated when saturated
- It is necessary to measure the fluoride concentration in the outlet water to know when to replace or regenerate media

Estimated Lifespan

- Estimating the lifespan can be made based on the fluoride concentration of the source water, the water volume filtered each day, and the adsorption capacity of the bone char
- According to Catholic Diocese of Nakuru Water Quality's laboratory research, the filter can be filled 200 times with water (using an inlet concentration of 6 mg fluoride/litre) before the fluoride concentration in the outlet water exceeds 1.5 mg fluoride/litre

Manufacturing Requirements

Worldwide Producers:

- Bone char is still produced in several countries as it is used in food industries such as sugar production

Local Production:

- Bone char can be produced locally in any country

Materials:

- Bones from animals
- Furnace or kiln
- Crushing machine or tools for manual crushing
- Sieves to obtain correct grain size for bone char media

Fabrication Facilities:

- Storage place with roof to keep bones dry

Labour:

- Anyone can be trained to produce bone char

Hazards:

- Safety precautions are needed when charring the bones

Maintenance

- Replacement or regeneration of bone char (skilled labour required)
- Cleaned on a regular basis

Direct Cost

Capital Cost	Operating Cost	Replacement Cost
US$17-23[1]	US$1.8/1000 litres[2]	US$1.8/1000 litres[2]

Note: Program, transportation and education costs are not included. Costs will vary depending on location.
1 CDN, 2006 for the whole defluoridation unit and depending on tap type, Kenya
2 For bone char media replacement (CDN, 2006)

Fluoride reduction technique comparison table

	Cost (Initial & O&M)	O&M burden	Skill required	Cultural / Acceptability	Local Availability	Durability	Environmental Impact	Other
RO								
limestone								
Dilution at point of use								
Dilution of groundwater								
Alternative groundwater source								
Alternative Surface water source								
Rainwater Harvesting								

Case Study 1:

Background

A village Kansali in District Nuh, located at the foothills of the Aravalli Range. The village relies on rain-fed subsistence agriculture. Village experiences significant runoff during the rainy season. The runoff merges with a nearby seasonal stream, contributing to the village's surface water resources during the monsoon by feeding a couple of ponds in a limited way. A major part of the run-off flows out very fast due to high ground gradients.

However, a local NGO recently discovered that the groundwater in the area contains dangerously high levels of fluoride, leading to widespread cases of fluorosis among the villagers. Fluorosis, caused by prolonged exposure to high fluoride levels in water, has resulted in dental and skeletal deformities, severely impacting the community's quality of life.

Challenges

1. High Fluoride Levels in Groundwater: Fluoride contamination is pervasive and has infiltrated all groundwater sources used for drinking and irrigation.
2. Lack of Awareness: Many villagers are unaware of the link between fluoride contamination and their health issues.
3. Economic Constraints: The village relies on agriculture and has limited financial resources to invest in large-scale water purification solutions.

Case Study 2:

Background

The village in Kamrup is located in the rocky terrain of district of Assam receives abundant rainfall spread over three seasons, providing a promising opportunity for water resource management because during the rains streets are flooded and muddy. Groundwater is also good at a shallow depth but with high fluoride content.

Village economy primarily depends on agriculture, with a focus on producing high-quality vegetable crops and pine apple orchards. Owing to good agricultural income, villagers lead a good quality life, living in spacious, cement-concrete-roofed houses. For domestic purposes water is supplied through the groundwater based local public water supply system.

Despite their agricultural success and comfortable economy, the community is grappling with yellow to brown spots on teeth and dental cavities, joint pain and bone deformity among elders. Elderly people avoid working in the field due to joint pains.

Key Challenges

1. High Fluoride in Groundwater: The main source of drinking water is contaminated, leading to widespread health issues.
2. Rainfall: Ample storm water from houses rainfall causes mud in streets.
3. Dependency on Agriculture: Fluorosis threatens the labour force and agricultural productivity.

Case Study 3:

Background

Located in a semiarid region of Rajasthan, the village receives scanty rainfall and faces significant water scarcity. The economy revolves around agriculture, with villagers cultivating pearl millet as their only crop annually. Additionally, animal rearing, primarily sheep and goats, provides supplementary income. The community relies on groundwater, which is contaminated with high fluoride content, leading to fluorosis and impacting both human and animal health.

Community has expressed that they are aware that the presence of fluoride in water is impacting their health. They are keen to adopt some treatment methods as they don't have any alternative source of water.

Key Challenges

1. Water Scarcity: Limited rainfall restricts alternative water sources.
2. Fluoride Contamination: High fluoride levels in groundwater cause severe health issues.
3. Economic Constraints: A monocrop economy and livestock dependence limit financial resources for large-scale interventions.

Case Study 4:

Background

The settlement in consideration, is a peri-urban area with well-developed infrastructure, including a reliable piped water supply. The residents are wealthy and enjoy a good standard of living with good household incomes.

Despite access to piped water, issues such as potential contamination with fluoride, iron, and nitrate have raised alarms within the community. Some residents suspect a connection between the water quality and various health problems they are experiencing.

Key Challenges

1. Multiple contaminants present in domestic water supply
2. Compact habitation area being peri-urban settlement
3. High land cost for putting up any new infrastructure

70 minutes total

Lesson Plan

Fluoride Symptom Management

Lesson Purpose

To help participants learn fluorosis management.

Learning Outcomes

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

1. List methods of managing fluorosis symptoms and understand recovery prospects.
2. Establish the relationship between fluorosis and anemia.
3. Recognize the role of nutrition in combating fluorosis.

Materials

- Whiteboard/flipchart
- Marker
- Picture cards
- Balanced diet chart
- Boat analogy picture
- Nutritional benefit picture of Moringa
- Nutrition garden calendar picture
- Fluorosis induced anemia picture

Preparation

- Write learning outcomes on flipchart paper
- Prepare PowerPoint slide with Sinking Boat image
- Prepare PowerPoint slide with Sher Singh story
- Prepare PowerPoint slide with nutritional benefits of Moringa
- Prepare PowerPoint slide with nutritional garden calendar
- Prepare PowerPoint slide with fluorosis induced anemia
- Print the balanced diet chart per participant

15 minutes

Introduction/Hook

Objective: Engage participants in thinking critically about how to manage increasing fluoride levels in the body.

Debate activity

1. Divide the participants into two groups and have them sit facing each other. Label one group as "Pro-Cure" and other as "Anti-Cure".
2. Explain the topic "Do you believe there is a cure for fluorosis?".
3. Instruct the "Pro-Cure" group discusses potential treatments and advancements in medical science that may lead to a cure and the "Anti-Cure" group discusses reasons why a definitive cure may not exist, including challenges in treatment and prevention.
4. Each group has 3 minutes to prepare. Afterwards, representatives from each group present their points and the facilitator leads a back and forth respectful debate.
5. Ask participants "*Do you believe there is a cure for fluorosis?"*

Trainer's Note:

Steer the discussion to highlight that early age detection and treatment may lead to cure otherwise there's no complete cure, managing symptoms is key to improving quality of life.

6. Explain that
    - High levels of fluoride that accumulated in the body over time is the **primary cause of fluorosis.**
    - While there may not be a definitive cure for fluorosis, **early detection and appropriate management** (like nutrition) can help alleviate its effects and improve quality of life.
    - It is important to learn that **fluoride is the underlying cause of fluorosis**, and managing exposure is essential in addressing the condition.

Sinking boat activity

1. Show the picture of Sinking Boat due to water accumulation on PowerPoint (slide 1)
2. Use a boat analogy:
    - "Imagine you are sailing in a boat that is taking on water through a hole. What will you do?"
    - Possible response may include:
        i. Search out the hole: the entry point of water coming into the boat
        ii. Stop the water coming into the boat through the hole
        iii. Throw the water out accumulated in the boat
        iv. Maintain the balance of the boat

3. Draw parallel between the boat analogy and managing fluoride levels:
    - **Search out the hole:** Identify the source of fluoride ingestion
    - **Block the source:** stop or minimize further fluoride ingestion (avoiding consuming high fluoride containing items)
    - **Remove excess:** implement strategies to reduce accumulated fluoride levels (detoxification methods)
    - **Maintain Balance:** maintain a balanced diet to mitigate the effects of fluoride (ensuring adequate intake of nutrients)
4. Encourage participants to share their thoughts on the analogy and ask questions like:
    - How do you think this analogy helps in understanding fluoride management?
    - Can you think of other strategies that relate to the boat scenario and managing fluoride levels in the body?
    - Strategy 1 and 2 are well in our control and we can do something, still some fluoride may be ingested while we further act on strategy 3 and 4.
    - For 3 and 4 let us go through another story from the jungle.

25minutes

Fluorosis and Nutrition

Objective: Get participants to consider straightforward methods for managing fluorosis through nutrition.

1. Tell the story of Sher Singh, the lion and Bubbly, his partner who brought back the harmony of the jungle.
2. Ask participants to reflect on how the story, with questions including:
    - How does Sher Singh's journey relate to managing fluorosis through nutrition?
    - Describe how the animals coped with the struggles and how the harmony was restored when Bubbly's presence brought peace and harmony in the jungle.
    - Compare this to how proper nutrition can create balance in the body and help mitigate the harmful effects of fluoride. (calcium and magnesium bonding with fluoride will neutralize its effect)
    - For strategy 4 (maintain balance) we need something to push out the fluoride accumulated in the body. Vitamin C and antioxidants are effective in doing so.

Trainer's Note:

Vitamin C supplementation is often combined with other dietary interventions, such as calcium and magnesium, to enhance the overall effectiveness of fluorosis management/treatment. Foods rich in vitamin C, like citrus fruits, guavas, tamarind, gooseberry and bell peppers, are also recommended in the diet of individuals suffering from fluorosis.

Antioxidant Properties:

Vitamin C acts as a powerful antioxidant, neutralizing free radicals generated by excessive fluoride exposure. This helps reduce oxidative stress and cellular damage caused by fluoride toxicity, boosts immune function, reduce fluoride absorption in the gastrointestinal tract, support the excretion of fluoride by improving kidney function, as the kidneys are responsible for filtering fluoride from the blood.

3. Discuss that calcium, magnesium, vitamin C, and antioxidants play a vital role in managing fluorosis by reducing fluoride accumulation and its toxicity, supporting bone health, and combating oxidative stress. A diet rich in these nutrients can significantly aid in mitigating fluorosis symptoms and promoting overall well-being.

1. Nutrition Wall Activity:
    - Distribute sticky notes to participants.
    - Ask them to write down **one nutritional element** they believe is key to managing fluorosis
    - Collect sticky notes and stick them on a flipchart labeled "**NUTRITION WALL**".
    - Categorize the nutrients: calcium, magnesium, vitamin C, antioxidants and others.
    - Briefly discuss the role of each category and mention foods that support fluorosis management including tamarind, lemon, and green leafy vegetables.
2. Discuss the role of Moringa leaves powder:
    - Explain that individual foods are rich in specific nutrients.
    - Show a picture of "**Moring**a" and discuss its nutritional benefits.
    - Moringa is a highly nutritious diet that can help mitigate fluorosis.

25 minutes

Preventing and Combating Fluorosis through Nutrition

Objective: Provide participants with practical ways to improve nutrition and discuss the development of a nutritional garden.

1. Present and discuss the foods that help prevent and combat fluorosis.
    - milk, tamarind, gooseberry, lemon, orange, flaxseed, turmeric, sesame & jaggery, green leafy vegetables, potatoes, tomatoes, and drumstick powder
2. Show a balanced diet chart and explain how each food supports fluorosis management.
3. Introduce the Nutritional Garden (take reference from picture attached):

- **Importance:** A nutritional garden can support the needs of the family or institution.
- **Size:** It should meet the family's nutritional needs.
- **Composition:** Focus on 50% fluorosis related foods and the remainder on daily nutritional needs.
- **Objective:** To provide nutritional support for fluorosis mitigation.

4. Remind participants that some plants absorb more fluoride from soil and water than others, food products from these plants should be avoided, especially in individuals with high fluoride exposure.
5. Plants that absorb fluoride and **should not** be grown in kitchen gardens in fluoride endemic areas include:
    - Leafy vegetables, like spinach, lettuce and cabbage
    - Root vegetables, like carrots, beets and radishes
6. Discuss the impact of fluoride on anemia (slide 5), particularly in pregnant women, via diminishing absorption of nutrition by weakend microvilli. Explain that drinking fluoride-safe water can help recover hemoglobin levels in anemic individuals.
7. Divide participants into three groups and ask them to brainstorm on the following topics:
    - Role of ANM and ASHA in combating anemia
    - Testing for anemia in pregnant women
    - Possibility of detecting fluoride in water
8. Allow groups to present their findings to the larger group.
9. Facilitate a discussion on the points raised by each group.

5 minutes

Review

1. Work individually to draw an ideal kitchen garden for fluorosis endemic areas.

Resources:

Slide 1: Boat Analogy

Slide 2: Sher Singh the Lion

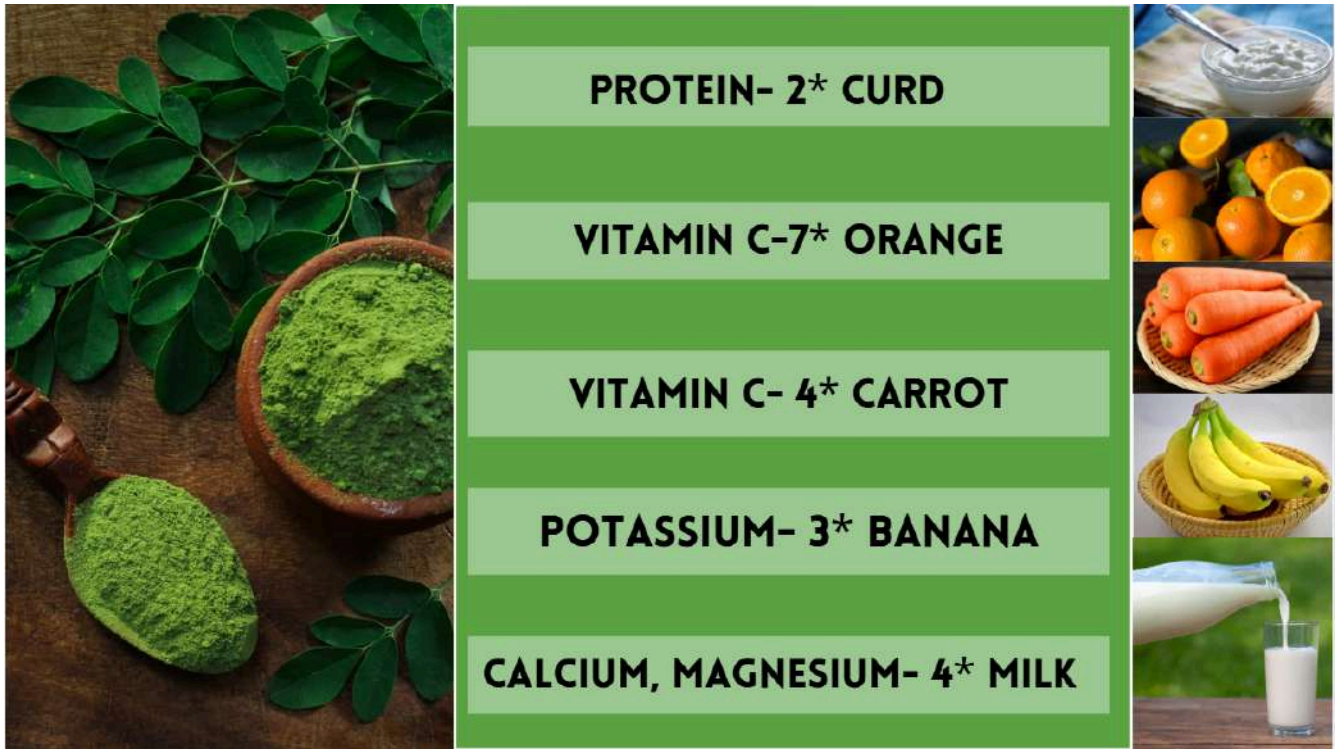
Once upon a time, in a peaceful jungle, the animals lived happily together, sharing the bounty of nature and enjoying each other's company. They thrived under the warm sun and cool shade of the trees. The animals gathered for the annual jungle meet to discuss important matters. This time, the topic was serious: the havoc caused by the new entrant, **Sher Singh** the Lion.

Coming from a big cat family, Sher Singh had powerful claws, teeth, and jaws for hunting prey. He wanted to adjust to life in the jungle, but his dangerous nature made fitting in with the other animals difficult. Mowgli, the man-cub, had been deep in thought during the meeting. The wise wolf asked him what was on his mind. Mowgli shared a solution from the human village: to calm Sher Singh's aggression by introducing a female into his life.

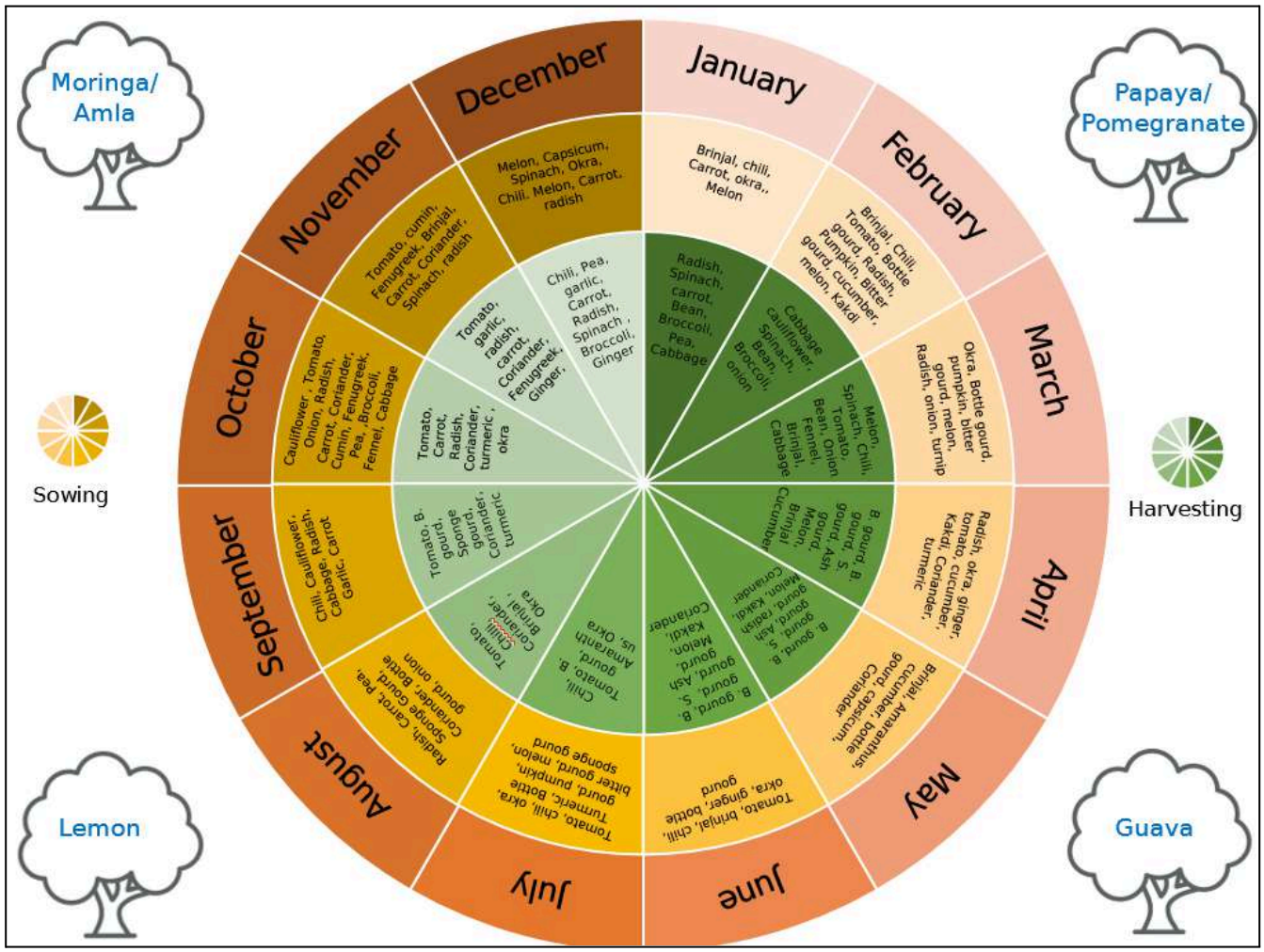
Inspired by Mowgli's idea, the animals decided to find a friendly lioness who could bring harmony to Sher Singh's life and other animals. They searched far and wide, never losing hope. After a week of searching, they found young lioness **Bubbly**, a perfect match for Sher Singh. She was kind and wise, and they believed she could help control Sher Singh's temper. After much convincing, Sher Singh agreed to marry Bubbly.

Their wedding was a grand celebration, and soon they started their family on the outskirts of the jungle. With Bubbly by his side, Sher Singh no longer disturbed the other animals. Harmony was restored in the jungle, and everyone thanked Mowgli for his brilliant idea.

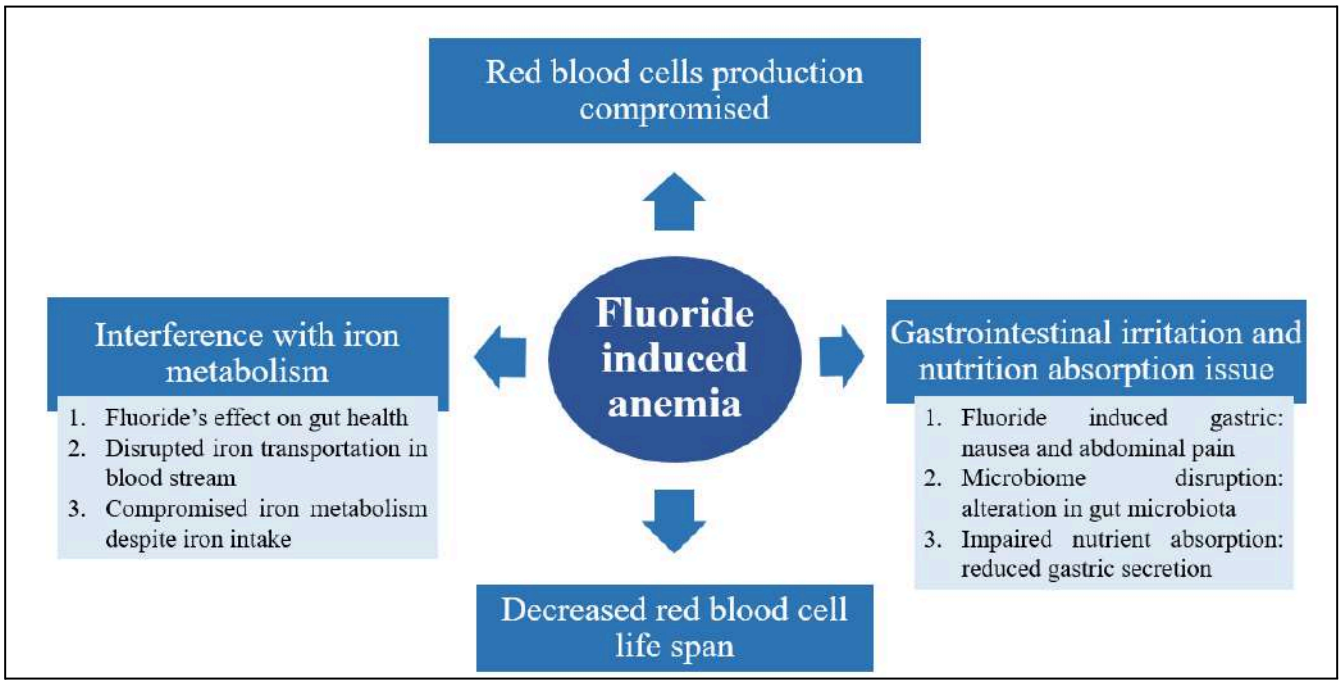
Slide 3: Nutritional benefits of Moringa



SLide 4: Nutrition Garden calendar



Slide 5: Relationship between fluorosis and anemia



Properties and benefits of vegetables given in Nutritional Garden			
S.No.	**Food Item**	**Properties**	**Benefits Related to Fluoride Mitigation**
1	Amaranthus	Rich in Iron, calcium, Fiber and vitamins	Assists in detoxification and may reduce fluoride absorption
2	Bitter Gourd	Medium in Vitamin A, Vitamin C, other Antioxidants and active compounds	Enhances liver detoxification and reduces fluoride toxicity
3	Bottle Gourd	High in Water content and low in calories	Promotes hydration and detoxification
4	Brinjal (Eggplant)	Rich in Antioxidants (Nasusin and anthocyanin), potassium and dietary fiber	Supports detoxification and helps reduce fluoride accumulation in the body
5	Broccoli	Rich in Vitamin C, Vitamin K, antioxidants, and fiber	Promotes detoxification and reduces oxidative damage caused by fluoride
6	Cabbage	Rich in Fiber, Vitamin C, Vitamin K and glucosinolates	Enhances detoxification and antioxidant defense
7	Capsicum	Rich in Vitamin C, carotenoids and antioxidants	Supports immune health and detoxification
8	Carrot	Rich in Beta-carotene and antioxidants	Enhances immune function and assists in reducing oxidative stress caused by fluoride toxicity
9	Cauliflower	Rich in Vitamin C, Vitamin K and glucosinolates	Promotes liver detoxification and reduces fluoride toxicity
10	Chili	High in Vitamin C and capsaicin	Vitamin C promotes detoxification by supporting kidney function
11	Coriander	Medium in Vitamin A, Vitamin C and Vitamin K, Flavonoids and antioxidants	Helps in chelation of heavy metals and toxins like fluoride
12	Cucumber	High in Water, antioxidants, potassium	Promotes hydration and helps eliminate fluoride
13	Fenugreek	Medium in Fiber, saponins, and antioxidants	Assists in detoxification and may reduce the impact of fluoride toxicity

14	Garlic	Medium in Sulfur compounds (Alicin) and antioxidants	Supports liver detoxification and may reduce fluoride's harmful effects
15	Ginger	Medium in Gingerol, an antioxidant	Aids in reducing oxidative stress and enhancing fluoride excretion
16	Guava	Rich in Vitamin C, fiber and antioxidants	Supports detoxification and enhances antioxidant defense
17	Kakdi (Indian Cucumber)	Rich in Water and fiber	Aids in flushing out fluoride through hydration
18	Lemon	High in Vitamin C and citric acid	Enhances fluoride excretion by supporting kidney function
19	Melon	High in Water, Vitamin A and antioxidants	Supports hydration, which aids in flushing out fluoride through urine
20	Okra (Ladyfinger)	Medium in Vitamin C, Mucilage, Fibre and antioxidants	May bind with toxins like fluoride and aid in their removal
21	Onion	Medium in Sulfur compounds and antioxidants	Enhances liver detoxification
22	Papaya	Rich in Carotene, Vitamin C, papain enzyme, and fiber	Promotes overall detoxification and gut health, reducing fluoride absorption
23	Pomegranate	Rich in Antioxidants and Vitamin C	Supports kidney health and detoxification
24	Pumpkin	Rich in Vitamin A, fiber, and antioxidants	Supports liver function and overall detoxification
25	Radish	Medium in Antioxidants and sulfur compounds	Supports liver detoxification processes
26	Spinach	High in Iron, calcium, and antioxidants	May assist in reducing fluoride absorption
27	Tomato	Rich in Vitamin C and lycopene	Reduces oxidative stress and supports detoxification
28	Turmeric	Medium in Curcumin, a powerful antioxidant	Known for its anti-inflammatory and detoxifying properties
29	Turnip	Rich in Antioxidants and Vitamin C	Aids in detoxification and reducing oxidative stress caused by fluoride

30	Cumin	Rich in Antioxidants, phenylpropanoids, terpenes, flavonoids, and anthocyanins	Some studies suggest that cumin may have protective effects against fluorosis due to its antioxidant and anti-inflammatory properties. It may help reduce oxidative stress induced by fluoride.
31	Pea	Rich in Calcium, protein and other minerals	Peas contain calcium, which can bind with fluoride in the digestive tract and reduce its absorption.
32	Beans	Rich in Calcium, protein and other minerals	Beans are a source of calcium and other minerals that may help in reducing fluoride absorption.
33	Sponge Gourd	High in Water content and potential diuretic properties	No specific studies directly link sponge gourd to fluoride mitigation. However, its high water content and potential diuretic properties might aid in flushing out toxins, including fluoride.
34	Ash Gourd	Medium in Antioxidants and diuretic properties	Ash gourd is known for its diuretic properties, which may help in eliminating fluoride through urine. Additionally, its alkaline nature might help in balancing the body's pH, potentially mitigating some effects of fluoride.

60 minutes total

Lesson Plan

Sensitization, Awareness Building, and Behaviour Change at Household level

Lesson Purpose

To help participants to develop a plan for effective **fluoride and fluorosis management,** focusing on sensitization, awareness-building, and **behavior change** at household level.

Learning Outcomes

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

1. Communicate effectively with households about fluoride issues and solutions.
2. Describe the six steps process of a household visit.
3. Create an action plan tailored to their local context.

Materials

- Whiteboard/flipchart
- Resource materials
- Sticky notes

Preparation

- Write learning outcomes on flipchart paper
- Print or draw hand illustrations for principal of household visit

10 minutes

Introduction

Objective: Explain to participants about **creating demand and encouraging new practices**.

1. Ask participants how we can create demand for change and encourage new practices. Probable answers:
    - Community meetings
    - Household visits for awareness building
    - Visual aids and storytelling to highlight the impact of fluoride on health
    - Water testing demonstrations so that community members can visualize the contamination
    - Identify village champions who are willing to be early adopters. They will influence the community through peer learning.
2. Explain the importance of household visit for **sensitization and awareness building at individual/family/ household level**.

15 minutes

Effective engagement at household level

Objective: Engage participants to think critically about effective **engagement at household level**.

1. Ask the participants if someone would like to be a volunteer for a scenario exercise to play the role of a member of a household family.
2. Ask the volunteer to stand in front of the group. Explain to the volunteers that they will play the role of household family members and must try to improvise answers. Explain to all participants that you will play the role of the Community WASH Promoter coming to the household to talk about fluoride issues.
3. If possible, change your attire to look more like a Community WASH Promoter (hold a clipboard, wear a hat, use posters, etc.)

> **Trainer Note:**
>
> You will play the role of a *very ineffective* Community Wash Promoter. This will mean being very rude, aggressive, condescending and insulting.

4. Approach the volunteers and greet them only briefly. Don't introduce yourself.
5. Begin talking *at* him/her regarding the issue of how their water is bad and contaminated with fluoride causing fluorosis among them. If the volunteer has any questions, pretend you did not hear what they said and continue talking about how they are putting their family at risk with such bad choices.

6. Tell the volunteer to show you where they collect water. If they refuse, demand that they show you.
7. Pretend that the household member is showing you their water source. Try to be disgusted by what they are showing you. Begin to list things that they are not doing correctly.
8. Pretend you are starting to become angry and disgusted by how the household member is living. Scold them for continuing to use the hand pump water for drinking and cooking.
9. Tell the volunteers that they need to listen to you and start collecting rainwater, protecting their pond, installing an RO system, purchasing treated water, etc. Make sure you are listing too many things for the beneficiary to change.
10. Tell the volunteer that they need to change all of these things or they will never be healthy and they will stay poor.
11. Say goodbye to the volunteer and walk out of the room.
12. Come back into the room and ask the volunteer to sit back in their seat.
13. Ask the volunteers, "How do you feel about the interaction?"
14. Ask the participants, "Do you think that my method for a household visit was effective? Do you think the household members will change their behaviour after my visit?" Most likely not.
15. Explain to participants that throughout this workshop we have been discussing problems and solutions related to fluoride impacts, exposure and management; however, we have not yet discussed how to motivate people to adopt new practices.

5 minutes

Sensitization and Awareness Building: At household level

Objective: Explain to participants the need for **sensitization and awareness building**.

1. Ask participants to reflect on what was the goal of the household visit in the role play?
    - Why wouldn't it have been effective?
    - Write their responses on the whiteboard, highlighting key insights.
    - What are some challenges that household members face when adopting new practices?

Trainer Note:

Lead the discussion to the potential barriers to behaviour change in their household.

10 minutes

Principles of a Household Visit

Objective: Get participants to consider the essential elements of a successful **household visit**.

1. Explain that household visits vary, but there are key steps to guide the process.
2. **Open hand illustration**

   Draw an open hand on the flip chart and explain how each finger will represent a step to remember during the visit.

   Step-by-Step Guide

   - **Thumb: Greeting**

     Ask participants to stick out their thumb.

     Ask, “What is the first thing we should do?”

     Answer: Politely greet the household, introduce yourself, purpose of visit and ensure it’s a good time to talk.

     Write “Greeting” next to the thumb.

   - **Index Finger: Understand**

     Extend your index finger and ask, “What’s next?”

     Answer: Identify and understand the household’s

     issues by asking questions, observing and listening.

     Write “Understand” next to the index finger.

   - **Middle Finger: Influence**

     Extend the middle finger. Ask, “Once we know the issues, what should we do?”

     Answer: Address the WASH issues to influence positive behaviour changes.

     Write “Influence” next to the middle finger.

   - **Ring Finger: Commitment**

     Extend the ring finger. Ask, “How can we help the household continue good WASH behaviors?”

     Ask participants to reflect on how the story relates to managing fluorosis through nutrition.

     Write “Commitment” next to the ring finger.

   - **Little Finger: Forms**

     Extend the little finger. Ask, “How can we track progress?”

     Answer: Use forms to track commitments and record progress.

     Write “Forms” next to the little finger.

   - **Goodbye**

     Wave your hand and explain that ending with a respectful, friendly goodbye leaves a positive impression with reaffirmation of commitment.

     Write “Goodbye” at the bottom of the hand.

10 minutes

Strategies for Sensitization and Awareness Building: At Household Level

Objective: Provide participants with actionable strategies for **sensitization and awareness building**.

1. Ask participants, "What types of support can we provide to household members to help make the changes easier."
    - Explain the use of IEC materials like posters, pamphlets, social media, and videos as tools for sensitization.
    - Identifying high-potential and realistic solutions that are tailored to the community context.
    - Demonstrate a few options so each household has autonomy, buy-in and can select what works best for them.
2. Split participants into small groups and come up with ideas for creating IEC materials that would resonate with their specific communities and have each group present their ideas. (Depending on time available for presentations, decide on the number of groups). Possible topics include:
    - Convincing community members that even though their water looks clear, it can still be contaminated
    - Understanding the health impact associated with fluoride ingestion
    - Presenting different options for defluoridation to a household
    - Use and maintenance of treatment technologies (choose one)
    - Creating customized diet plans

Presentation should include IEC material, ideas that can create maximum influence on existing thought process, time/location aiming maximum outreach, outcome action strategy towards solution once influenced.

3. For their topic, ask participants to outline:
    - IEC ideas (games, posters, stories, household visits, water testing demonstrations, sessions in schools etc.)
    - Key messages
    - Target audience

15 minutes

Household Visit Roleplay (Optional)

1. Pair participants to practice the five principles in a role-play scenario being an **effective** community WASH promoter and a household member discussing fluoride issues in the household and possible solutions.

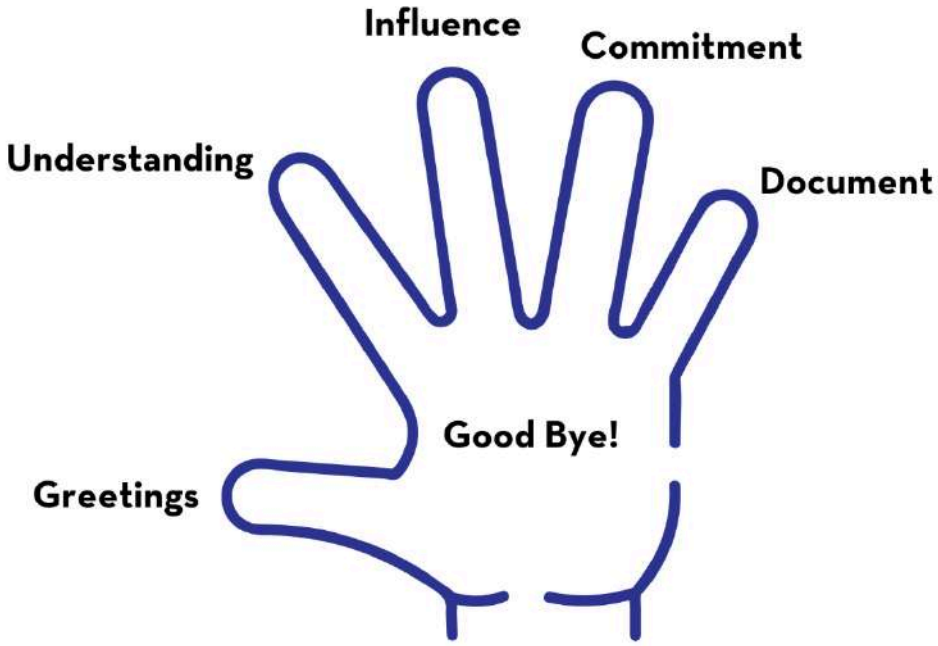
2. After each roleplay, switch roles and then discuss effective strategies and improvements as a group.

5 minutes

Review

1. Ask participants to think and share with their partner about IEC material they developed to sensitize at household level.

Resources:


Influence
Commitment
Understanding
Document
Good Bye!
Greetings

50 minutes total

Lesson Plan

Sensitization, Awareness Building, and Behaviour Change at Community Level

Lesson Purpose

To help participants to develop a strategy for effective **fluoride and fluorosis management,** focusing on sensitization, awareness-building, and **behavior change** in the community.

Learning Outcomes

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

1. Communicate effectively with the community about fluoride issues and solutions.
2. Develop a strategy tailored to their community context.

Materials

- Whiteboard/flipchart
- Resource materials
- Sticky notes

Preparation

- Write learning outcomes on flipchart paper
- Prepare PowerPoint slides
    - Formative research
    - Focused Group Discussion
    - Community meetings

10 minutes

Introduction

Objective: Engage participants to reflect on the limitations of individual behavior change and the importance of collective action in addressing fluoride contamination at the community level.

1. **Ask reflection questions**

Start by asking participants to think and respond on the following:

   a. Is conducting household visits alone enough to mitigate fluoride exposure?
   b. Can individual behavior change influence safety in shared spaces, facilities and services like common water sources, school and health services?
   c. Why is it essential to encourage behavior change at the community level while addressing fluoride contamination?

2. **Summarize few takeaway from their responses with the following points**:
   a. **Fluoride in water is a shared challenge**: While individuals can use household filters or change practices like nutrition management, the source of the water (hand pumps, wells, or piped supply) often remains contaminated. If that common source is not addressed, the exposure may incur at some point of time.
   b. **Identification and recommendation of alternate fluoride safe sources** (take reference from lesson plan 07)
   c. **Management requires both individual and collective efforts**: Effective fluoride management is not only about what we do at home but it is about community-level efforts too. When communities take action together by looking for safe water, participating in awareness drives, or adopting source treatment options, behavior change within households and beyond, change is more visible and lasting.
   d. **The Power of Sharing and Supporting**: Just as we share meals or water, we can also share knowledge, solutions, and support in mitigating the exposure. Collective efforts help fluoride-related messages travel faster and reach wider audiences building a more fluoride awareness to build a better resilience in a community.

15 minutes

Sensitization and Awareness Building: At a Community Level

Objective: To help participants realize that individual actions reduce fluoride ingestion but sustainable fluorosis mitigation requires community efforts and convergence among all stakeholders.

1. Storytelling- A tale of two households
   a. **Household A** had installed rainwater harvesting structures years ago. Their tanks were brimmed in monsoon with fluoride safe water keeping their family healthy. Whereas, **Household B** relied on a deep borewell with fluoride contaminated water leading to severe fluorosis over time. Then came a year with no rain, tanks of household A dried up. Household B continued using the same fluoride contaminated water. Both the households are now facing challenges. Household A is dealing with scarcity and chemical contamination while Household B is struggling with ongoing chemical contamination in their

water supply. A silent reminder that water security is not just about quantity but quality too.

b. Prompt the discussion on the following questions:
   i. Can every household depend on its own rainwater harvesting structure?
   ii. What happens when the tanks dry up?
   iii. What about families with no space or resources for rainwater harvesting structures?
c. Bring the realisation towards "***Household level action is good but not good enough. We need community level action too***".

Trainer's note:

Discuss and explain the household level action points to the participants.

1. **Point of Use Water treatment**
   a. Install household defluoridation filters to reduce fluoride levels in drinking and cooking water.
   b. Encourage the use of safe water sources, such as rainwater harvesting systems, to supplement or replace contaminated groundwater .
2. **Nutritional Intervention**
   a. Promote the consumption of calcium-rich foods (e.g., milk, green leafy vegetables) and vitamin C-rich foods (e.g., citrus fruits) to help mitigate the effects of fluoride.
   b. Advise against the use of rock salt and fluoridated toothpaste, as they may contribute to excessive fluoride intake .
3. **Behavioral Change**
   a. Encourage families to use safe water for drinking and cooking, and to avoid using contaminated water sources.
   b. Promote the use of fluoride free water for preparing food to reduce fluoride exposure.
4. **Health monitoring and medical support**
   a. Provide access to medical screening for fluorosis symptoms and offer appropriate treatment, including nutritional supplementation.
   b. Establish support centers for the maintenance of defluoridation units and to offer guidance on managing fluorosis cases

d. Split the participants into small groups and ask them to brainstorm on "What community level interventions can help us stay safe during water scarce or drought years and fight against fluorosis?" Write the responses on the flipchart paper.
e. Possible interventions to be discussed (facilitator take reference from trainer's note):
   i. community water solutions
   ii. awareness and behavior change
   iii. monitoring and surveillance
   iv. efforts for convergence among stakeholders

Trainer's note:
Community level action points:

1. **Community water solutions**:
   a. Shared rainwater harvesting at schools, panchayat buildings, anganwadis
   b. Fluoride-safe mini piped water supply or borewell with defluoridation unit
   c. Village water safety plan including source dilution
2. **Awareness and behavior change**:
   a. Public reminders/posters at schools, temples, panchayat offices about fluoride-safe water
   b. Safe water and nutrition messages during community events
   c. Community members support each other in adoption of fluoride safe behavior
3. **Monitoring and surveillance**:
   a. Regular fluoride testing by trained local youth
   b. Mapping safe and unsafe sources in the village
   c. Reporting of suspected fluorosis cases
4. **Convergence among stakeholders**:
   a. Health Dept: ANMs, ASHAs support fluorosis screening, nutrition counseling
   b. Education Dept: Safe water in schools, RWH units, educating about fluoride and fluorosis
   c. WCD/ICDS: Anganwadi-based safe water and nutrition
   d. Rural Development/Panchayat: Implement RWH tanks or fluoride mitigation plans, mass recharging
   e. NGOs: Technical support, training, behavior change campaigns

20 minutes

Strategies for Sensitization and Awareness Building: At a Community Level

Objective: To develop actionable strategies for community sensitization and awareness building regarding fluoride and fluorosis, using various tools and methods tailored to different community segments.

1. Divide participants into two groups, each assigned to different parts of the strategy.
   - **Group A** will focus on data collection and engagement methods for the initial sensitization stages (research, discussions, and participatory methods).
   - **Group B** will focus on practical information dissemination and media engagement, along with community-based behavioral nudges.
2. Briefly introduce the issue of fluoride and fluorosis in the community. Explain that excessive fluoride in drinking water can cause various health problems, and fluorosis can affect teeth and bones, particularly in areas where water sources are contaminated.
3. Explain that the goal of the activity is to create effective strategies for raising awareness in the community about fluoride contamination and fluorosis.
4. Use PPT slides to display the guiding steps:

   Slide 1: Formative research

   - Collect secondary data to better understand the situation of fluoride and fluorosis in the community (village water sources/supply, village institutions, health offices, school teacher, and village health workers).

- Understand the extent of fluoride contamination and the community's knowledge of fluorosis.
- Identify the key individuals or groups in the community who can support or lead awareness efforts

Slide 2: Focused Group Discussion (FGD)

- Engage community representatives from different segments to gather insights on their understanding and practices related to fluoride and fluorosis.
- Conduct FGDs with different groups (e.g., youth, elderly, women, teachers, health workers) to assess their knowledge and perceptions.
- Design sensitization meetings based on the findings of these discussions.

Slide 3: Community Meetings

- Use Visual and Interactive Communication Tools
- Engage Local Influencers and Champions
- Conduct Participatory Workshops: Interactive Sessions (Use storytelling, group discussions, and demonstrations), Games and Activities (Use games or quizzes to reinforce key messages and encourage community involvement).
- Disseminate simplified Technical Information: Fluoride and Fluorosis link, Fluorosis symptoms, dietary advice
- Engaging community to Leverage Local Media (Community Radio, Pamphlets and Flyers, Public Announcements, Demonstrate Practical Solutions, promote Safe Water Sources, creating Behavioral Nudges etc)

Group work:

1. Divide the Participants into two Groups:
    - Group A will focus on:
        i. Formative Research (Slide 1)
        ii. Focused Group Discussions (Slide 2)
        iii. Develop ideas for how to conduct effective research for assessing the situation and conducting community meetings.
    - Group B will focus on:
        i. Community Meetings (Use Slide 3)
        ii. Develop strategies to simplify technical information for the community understanding and plan media campaigns or other awareness efforts.
        iii. Interventions to support sustained behaviour change
2. After both groups present, open the floor for feedback and questions.
3. Encourage participants to give constructive feedback on each other's strategies.
4. Ask questions like:

- Are there any suggestions for improving the IEC materials created by both groups?
- How can we ensure that the local community is truly engaged in the process?

5 minutes

Review

1. Ask participants to think and share with their partner about adapting their strategies to their specific communities.

35 minutes total

Lesson Plan

Action Planning: Fluoride and Fluorosis Management

Lesson Purpose

To engage participants in critically considering the challenges and opportunities in managing fluoride and fluorosis in their communities, and to develop action plan to mitigate the issues.

Learning Outcomes

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

1. Describe the key challenges of fluoride and fluorosis
2. Create a comprehensive action plan to address the issue
3. Assess the effectiveness of strategies implemented in their communities.

Materials

- Whiteboard/flipchart
- Action plan template
- Sticky notes

Preparation

- Write learning outcomes on flipchart paper
- Prepare PowerPoint with small village scenario
- Prepare PowerPoint with action plan template

10 minutes

Introduction

Objective: To develop an action plan for managing fluoride and fluorosis and present an overview of fluoride contamination and its health effects on communities.

1. Present a brief scenario to the participants (read aloud or display on a PowerPoint to participants:
    - "In a small village of 150 households, stained teeth and crippling joint pains plagued the residents. Adults complained of relentless joint pain, and some, as they aged, found themselves unable to walk properly. Bent legs and deformed spines became more common, leaving many bedridden.

      Whispers spread, this was not just a natural occurrence. Some elders began to believe the village was cursed. Reena, a young school teacher, refused to accept this explanation. Suspecting the hand pump water, she tested the water of one hand pump and discovered dangerously high fluoride levels."
2. Allow participants 2-3 minutes to read the scenario and think critically about the challenges faced by the community.

> **Trainer Note:**
>
> Encourage groups to think about challenges connected to sensitization, awareness building, community involvement, implementation, and monitoring.

20 minutes

Action Plan Discussion

Objective: Deepen understanding of the steps for effective action planning in fluoride and fluorosis management.

1. Divide participants into four groups.
2. Each group should identify the challenges faced and brainstorm potential solutions which might include:
    - Identification of problem/source
    - Knowledge sharing
    - Symptom management
    - Water testing
    - Media use for awareness
    - Suggestions to the community
3. Once the group has listed out potential solutions, ask them to categories into **four action plan themes**. These could include:
    - Situation Analysis

- Sensitization and Awareness Building
- Solution Designing
- Monitoring and Evaluation (Sustainability)

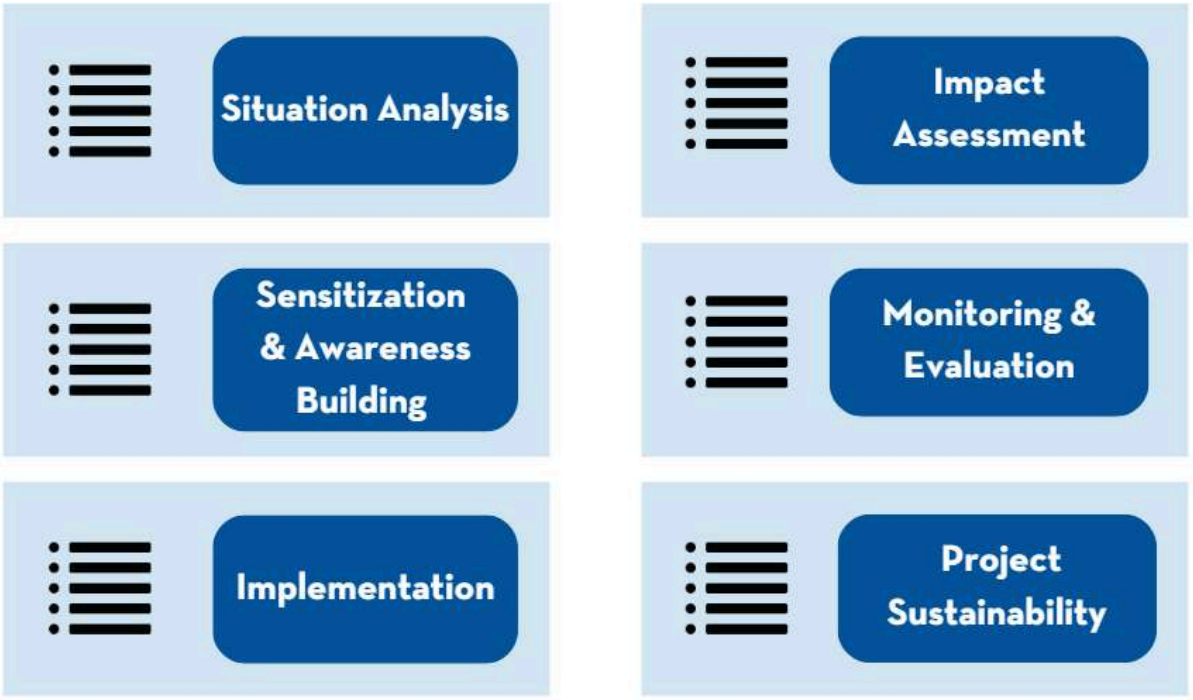
4. Assign each group one of the four action points to develop a detailed action plan.
5. Each group's action plan should include:
    - **Specific steps** to address their assigned action point
    - **Roles and responsibilities** for implementing action steps
    - **Timeline for implementation**
    - **Resources needed**
    - **Potential challenges and solutions** to overcome
6. Have each group present their action plan to the larger group.
7. The presentation should include:
    - Key steps for addressing assign action point
    - Expected outcomes
    - Resources and support needed
    - Potential challenges and solutions
8. After each presentation, allow time for feedback and questions from other groups.

5 minutes

Review

1. Ask participants to partner up with someone from another group and discuss how they could adapt the action plans presented to their own specific community contexts.

Resources:


Situation Analysis
Impact Assessment
Sensitization & Awareness Building
Monitoring & Evaluation
Implementation
Project Sustainability