WATER AND HEALTH

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OBJECTIVES

Unit 3: Water and the Human Health

- **Testing Water Quality**
- **Solutions to improving Health**

Unit 4: The Opportunities and the Gaps

- **Water Policy**
- **Social Justice**
- **The Science and The Business**

TESTING WATER QUALITY

SAMPLE COLLECTION

- Samples for metal analysis can be collected in a plastic bottle.
- Samples for volatile organics and pesticides analysis are collected in glass containers. They require vials to ensure the analytes stay dissolved in the water,preventing it from escaping.
- Bottles used for samples for bacteria testing should be sterilized.
- The size of the container should important to ensure there is enough water for testing.
- Dark bottles are required for analytes that breakdown in sunlight.
- A common preservative used is sodium thiosulfate used to stop any chlorine reactions.
- Hydrochloric acid is used to preserve volatile organics from microbial activities.
- Documentation is critical and should include date,time and location

Water quality testing can be broken down into three categories:

- **Physical tests** obvious changes in the water that are easily detectable by the senses. This include changes in colour, odour, taste and turbidity.
- **Chemical tests** involves the quantification mineral and organic substances that affect water quality. This include pH, hardness, highly toxic chemical and biological oxygen demand.
- **Bacteriological tests** show the presence of bacteria, characteristic of faecal pollution.

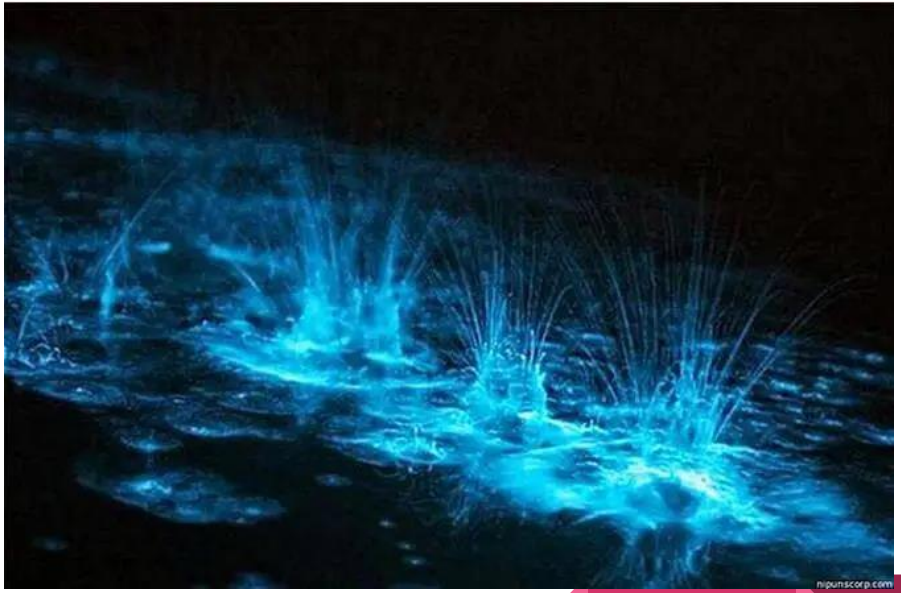
N.B. All samples for analysis should be collected in a sterile container.

PHYSICAL TESTS-COLOUR

- The colour of the water is depended on the quantity of dissolved ions or suspended materials present.
- The water we drink contains a wide variety of dissolved ions that are beneficial to the human body.
- A simple at home test is to catch a glass of tap water. If you realize after couple minutes the water will become change from milky white to clear. The interaction of the water with the bubbles and pressure in the water line.

HOW DOES THE ENVIRONMENT AFFECT THE WATER COLOUR?

- Natural water will never be clear they will have varying colours.
- The colour of the water can be impacted by the presence of suspended solids and dissolved ions.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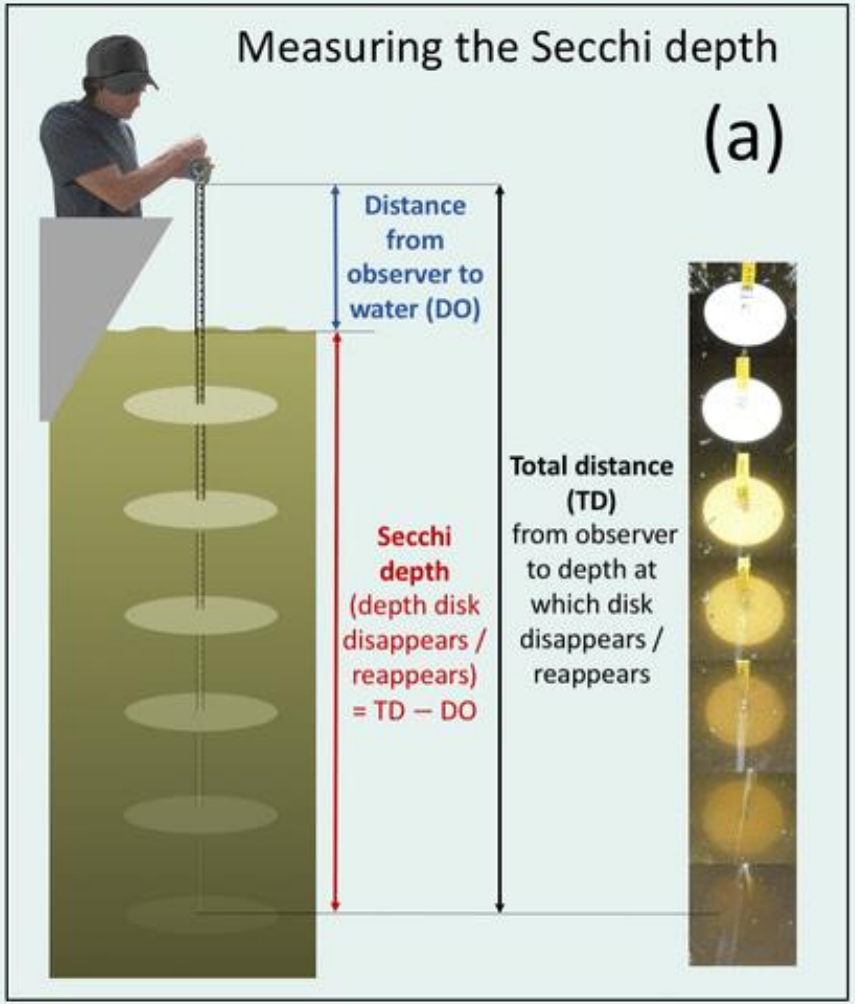
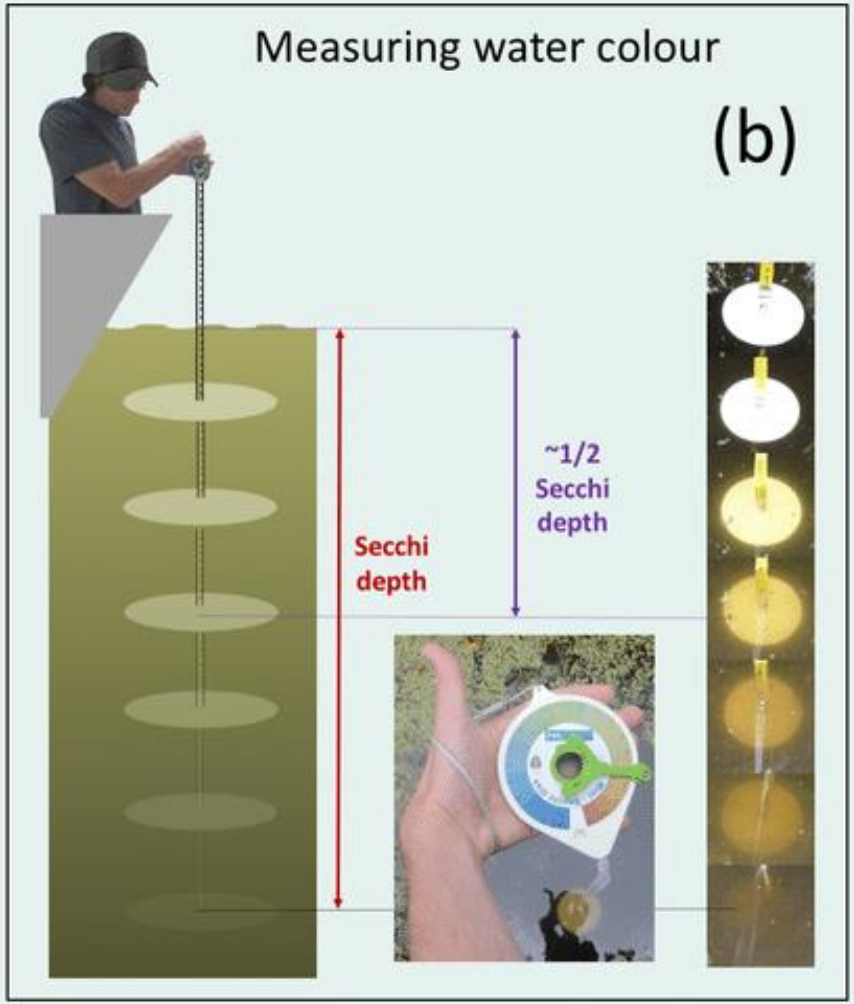

Measuring the Secchi depth
(a)
Distance from observer to water (DO)
Secchi depth (depth disk disappears / reappears) = TD − DO
Total distance (TD) from observer to depth at which disk disappears / reappears


Measuring water colour
(b)
Secchi depth
~1/2 Secchi depth

PHYSICAL TEST- ODOUR AND TASTE

- Humans tend to use their senses for diagnostic purpose first. Foul smell and bad tasting water are clear signs of impurities. Some common examples are:
  - Hydrogen Sulfide- A rotten-egg or sulfur smell or taste and a salty taste. This is caused by specific bacteria growth in the drains or pipes.
  - Decaying organic material in the pipe can cause musty,earthy odour.
  - The water may smell or taste like chlorine because that's the method of purification used here in Jamaica.
  - The presence of metals such as zinc, lead,mercury and copper can cause the water to have a metallic taste. The source may be the corrosion of the pipes (metal).
  - The water may taste salty due to the high sodium concentration.
- Example: Ferry River located by Mandela

HOW TO TEST FOR SALINITY?

- Salinity refers to the total concentration of all ions in water. Hydrometer that have been calibrated versus different salinity are available.
- The concentration of dissolved ions can affect the refractive index so therefore, a refractometer can be calibrated against salinity concentration to estimate the salinity.
- Hydrometer and refractometer is not 100% accurate at salinities below 3 or 4 ppt (parts per thousand).

CHEMICAL TEST- pH

- pH represent the concentration of hydrogen ions in a solution. A solution can either be acid (0-6) ,netural (7) or alkaline (7-14). As the pH decreases the acidity of the solution increase whereas when the pH increases the alkalinity increases.
- Acid and bases can be dangerous to humans and the aquatic environment.

HOW DO WE TEST pH ?

- A pH probe or litmus paper or pH strips can be used to determine the pH.

  N.B. The pH probe needs to be calibrated before use.

1. The pH probe should be stored in a storage solution or a pH 4 solution. If this is not the case, soak the probe in distilled water for at least 24 hours.
2. Turn on the pH meter is set in pH mode, and then rinse the probe of your meter in distilled water. Shake it off before placing it in a pH 7 solution for calibration.
3. Let the probe remain in the solution for at least 30 seconds to allow time for the meter to stabilize, and then adjust the meter so that it reads pH 7.
4. Rinse once again and then place it into a pH 4 solution, giving time for the meter reading to stabilize. Adjust the meter so that it reads pH 4. Your meter has now been calibrated.
5. Rinse the probe once again and shake off any excess liquid. The probe is now ready to be placed in your sample liquid.

HOW DO WE TEST pH ?

6. After allowing the pH reading to settle as you have done before, take the pH reading of your sample.

7. Store the probe in storage solution or a pH 4 solution when finished measuring.

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USING LITMUS PAPER

- Litmus paper comes in two colour red and blue.
- Neutral solutions should not cause a change in the litmus paper colour even though, for some manufacturers neutral solution cause a purple colour change.
- A small drop of water sample is placed on the litmus paper or you can submerge the tip of the litmus paper into the small amount of water sample.
- Red Litmus paper turns blue with bases.
- Blue litmus paper turns red with acids.

Acids turn blue litmus paper red

Alkalis turn red litmus paper blue

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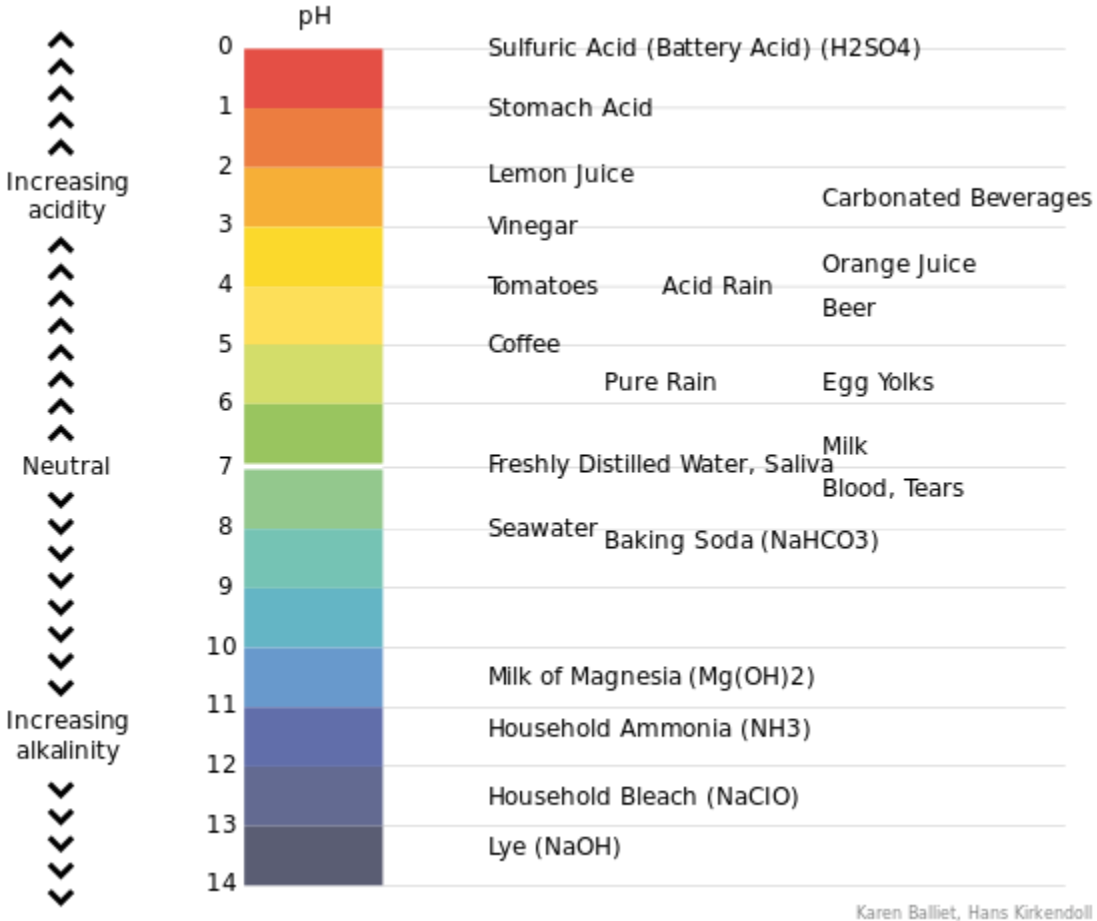
USING pH STRIPS ?

- The pH strips determine the pH value.
- Submerge on end of the pH strip in a sample of the water to be tested then remove it after the appropriate length of time.
- Compare the colour of the strip to the chart. Each colour is associated with a number.
- Acids - warm colors (such as red and orange)
- Alkalines- cooler colors (such as blue and green)



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CHEMICAL TEST- BIOLOGICAL OXYGEN DEMAND

- By using the naked eye we can get a slight idea of the biological oxygen demand of the water.
- As the colour of the water becomes darker the quantity of oxygen penetrating the water decreased.

HOW DO WE TEST FOR BIOLOGICAL OXYGEN DEMAND?

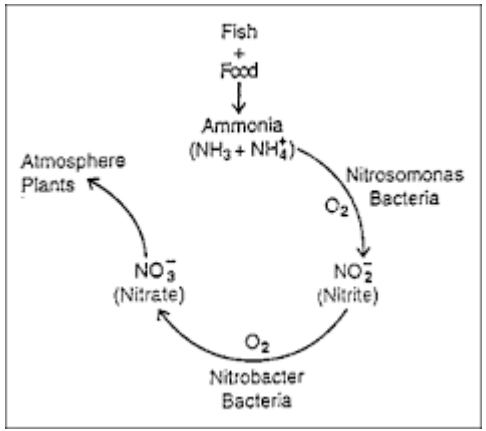
- There is a laboratory procedure that measures biodegradation.
- A technician will place a small water sample in a small bottle about the size of a canning jar.
- The amount of dissolved oxygen is measured and the bottle placed in a warm room for five (5) days.
- During the five (5) days a naturally occurring bacteria is added to the bottles to start the degradation of the organic material present.
- The dissolved oxygen present in the bottle will be used up by the bacteria during its natural processes.
- The technician will come back at the end of the five (5) days and measure the dissolved oxygen present.
- This method is a direct measurement of the dissolved oxygen and a indirect measure of organic materials.

HOW TO INTERPRET THE RESULTS

- As the organic matter increases the quantity of dissolved oxygen decreases because the bacteria consuming the oxygen.
- To calculate BOD, subtract the final amount of dissolved oxygen from the initial amount of dissolved oxygen .
- This is the amount of oxygen that has been used, or demanded, by microbes during the 5-day incubation period.
- Unpolluted natural waters will have a BOD of 5 mg/L or less. This is because the demand for the dissolved oxygen would be decreased.
- So therefore, dissolved oxygen and biological oxygen demand can be used to determine if the water body is safe for human consumption.

CHEMICAL TEST -NITRITES, NITRATES, AMMONIA

- All plants and animals needs nitrogen for the formation of amino acids.
- Nitrate concentration in the groundwater can increase because of anthropogenic activities such as pit latrines, failing septic tanks, runoff from animal manure storage areas, fertilized of croplands.



HOW DO WE MEASURE NITRATES ?

- Nitrates can be measured by first measuring the quantity of nitrite in the sample.
- Nitrate is then reduced to nitrite then the combined nitrite concentration (initial plus reduced nitrate) is measured from which the original concentration of nitrite is subtracted.
- From this the nitrate concentration can be determined.
- Increased nitrates can lead to increasing eutrophication which degrades the water quality.
- If the nitrate concentration is greater than 10 mg $NO^{3-}N/L$ the water is not fit for human consumption.
- If infants consumes water with too much nitrates they will develop methemoglobinemia (blue baby disease) the nitrates reduce the amount of oxygen carried by the red blood cells. This can lead to death.
- When adult consume nitrate concentration greater than 10 mg $NO^{3-}N/L$ they might not have the same response as infants because they have fill developed respiratory systems.

CHEMICAL TEST- TOXINS

- Toxins are detrimental to water quality.
- Chlorine is one of the most toxic chemicals used to kill harmful bacteria and viruses.
- High level of chlorine can be detrimental to human health however, low levels of chlorine are safe for human consumption.
- Ammonia another common toxic compound and it is formed from the breakdown of organic materials containing nitrogen.
- Toxic compounds can have both long (chronic toxicity) and short term effect (acute toxicity).
- One common example is the bioaccumulation of mercury.

HOW TO TEST FOR TOXINS?

- Bioassays can be used to determine the level of toxicity.
- The technician will place small organisms in the water e.g. industrial effluents.
- They then monitor the health of organisms to determine the effect of the concentration on the organism.
- Toxicity can be measured as weight loss, reduced reproduction or mortality.

SUMMARY OF ACCEPTABLE LIMITS FOR DRINKING WATER

Table 3: Acceptable Limits for Contaminates in Water

BENEFICIAL USE	PARAMETERS	ACCEPTABLE LIMIT	SOURCE
	Nitrate	< 50 mg/L	World Health Organization Guidelines for Drinking Water, 2011,
	Chloride	< 250 mg/L	
	Sodium	< 200 mg/L	
	Sulphate	< 400 mg/L	
	Total Dissolved Solids	< 500 mg/L	US EPA Drinking Standard

A Quick Look at Safe Levels in Drinking Water

(most are based on EPA recommendations)

mg/l means milligrams per liter

Coliform bacteria	No coliform bacteria is acceptable
pH	6.0 to 9.5*
Nitrates	Less than 10 mg/l as NO3 –N Less than 45 mg/l as NO3
Total dissolved solids (TDS)	Less than 1,500 mg/l
Chloride	Less than 250 mg/l
Fluoride	0.7 – 1.2 mg/l
Calcium and magnesium	Calcium – limits not set by EPA Magnesium greater than 125 mg/l may show laxative effects
Iron and manganese	Iron less than 0.3 mg/l Manganese less than 0.05 mg/l
Sodium	Less than 100 mg/l
Sulfates	Less than 250 mg/l
Arsenic	Less than 10 parts per billion
Conductivity	Less than 2.1 millimhos per centimeter
Total hardness	Less than 270 mg/l
Turbidity	1 turbidity unit (TU). *Note: greater than 5 TUs are detectable easily in a glass of water and usually are objectionable for aesthetic reasons.*
Potassium	No maximum limit has been set
Color	Less than 10 color units

* Many **public** water supplies in North Dakota use lime-soda softening in one step of the water treatment process. To comply with the U.S. Environmental Protection Agency Lead and Copper rule and prevent leaching of these elements from piping systems, they have to maintain the pH above 9 to be effective.

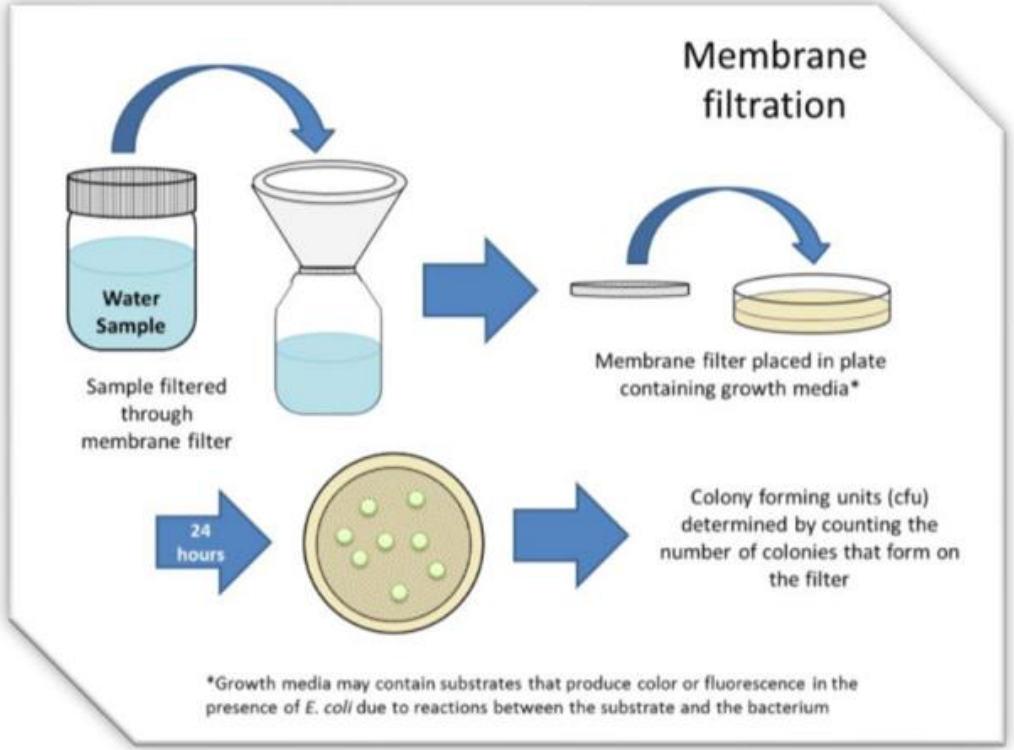
FECAL COLIFORM TEST

- Coliform are bacteria found in the digestive tract of humans and animals.
- Fecal coliform contamination is a serious problem because of the potential of contracting diseases through pathogens.
- It is not practical to test for pathogens so therefore, coliform which comes from the same pathogen is used as a indicator organism.
- The total coliform test can be used to test for the bacterial contamination of the water supply.
    - ***Total coliform*** which includes the coliform found in the soil and water influenced by surface water.
    - ***Fecal coliform***- total coliform found in the guts and feaces of warm-blooded animals.
    - ***Escherichia coli*** is the best species of bacteria to indicate fecal contamination and the presence of the pathogens

HOW TO TEST FOR FECAL COLIFORM

- Water samples to be tested should be collected in sterile containers.
- Samples collected should be analyzed within 6 hours after collection and kept on ice during transport.
- The sample collected can be analysed using:
  - Membrane filtration
  - Multiple tubes/multiple well
  - Multiple tube fermentation

MEMBRANE FILTRATION



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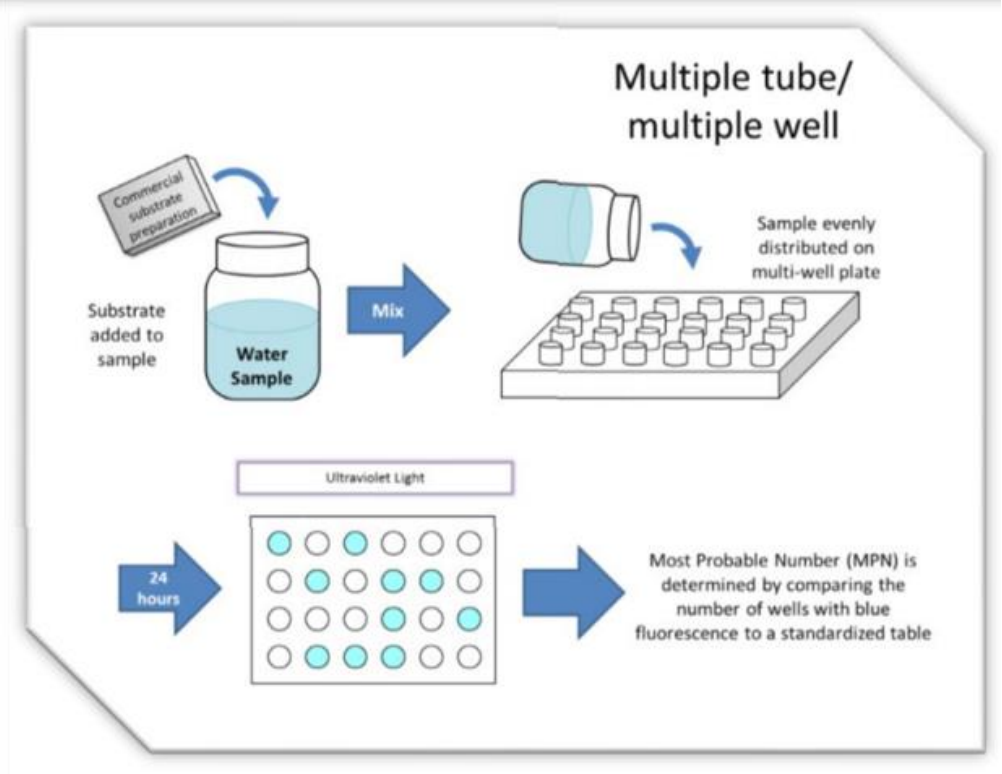
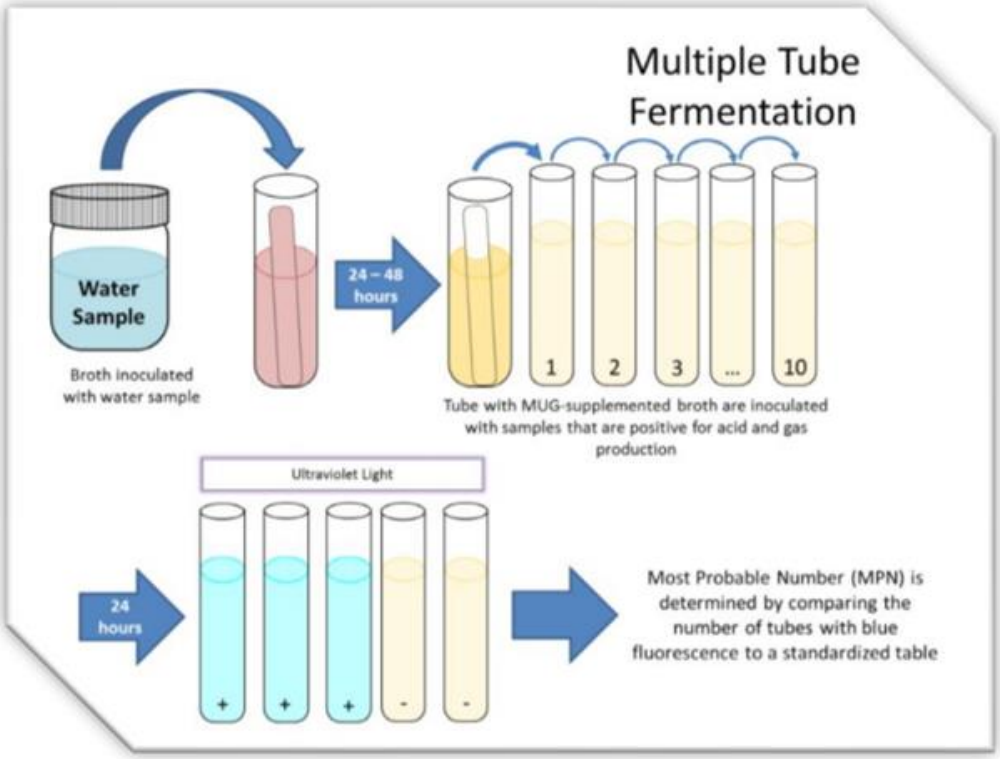
MULTIPLE TUBES



MULTIPLE TUBE FERMENTATION



HOW TO INTERPRET THE RESULTS?

SAFE WATER	
• No significant evidence of bacterial contamination • Total coliforms : ≤ 5 • E. coli: 0	Three consecutive samples with this designation, collected one to three weeks apart are required to determine the stability of the water supply. The water is considered safe to drink.
UNSAFE WATER	
Total coliforms: ≥ 5 E. coli: 0	Significant evidence of bacterial contamination. May be unsafe to drink.
E. coli > 0	Unsafe to drink. Evidence of fecal contamination.
Overgrown (O/G)	The crowding of bacterial growth prevents the laboratory from accurately identifying the presence of E. coli or total coliforms.

SOLUTIONS TO IMPROVE HEALTH

UNICEF FACTS

- 1 in 4 health care facilities lacks basic water services
- 3 in 10 people lack access to safely managed drinking water services and 6 in 10 people lack access to safely managed sanitation facilities.
- At least 892 million people continue to practice open defecation.
- Women and girls are responsible for water collection in 80 per cent of households without access to water on premises.
- Between 1990 and 2015, the proportion of the global population using an improved drinking water source has increased from 76 per cent to 90 per cent
- Water scarcity affects more than 40 per cent of the global population and is projected to rise. Over 1.7 billion people are currently living in river basins where water use exceeds recharge.
- 2.4 billion people lack access to basic sanitation services, such as toilets or latrines
- More than 80 per cent of wastewater resulting from human activities is discharged into rivers or sea without any pollution removal
- Each day, nearly 1,000 children die due to preventable water and sanitation-related diarrheal diseases
- Approximately 70 per cent of all water abstracted from rivers, lakes and aquifers is used for irrigation
- Floods and other water-related disasters account for 70 per cent of all deaths related to natural disasters

UNICEF GOAL 6

- The quality of drinking water consumed is paramount to public health so therefore steps should be taken both at the government and individual level to ensure excellent water quality is maintained.
- UNICEF listed Clean Water and Sanitation (Goal 6) on their list of sustainable development goals.
- These goals are a call to action to create a world where no one is left behind.
- One of the leading of death amongst kids under 5 is contaminated water and poor sanitation.
- There is an increasing risk of preventable diseases and malnutrition and other critical illness without proper water, sanitation and hygiene.
- UNICEF aims to bring clean water, basic sanitation and hygiene to homes and school in order to create a safe environment that children can grow.

POOR WATER QUALITY AND HEALTH

- Consuming quality drinking water will prevents the risk associated with getting water- borne diseases such as: cholera, diarrhea and gastroenteritis.
- Exposure to chemicals in drinking water can lead to a wide variety of chronic diseases such as cancer,cardiovascular diseases, adverse reproductive outcome and effects of children’s health.
- This can lead to death amongst younger children.
- Malnutrition

GOOD WATER QUALITY AND HEALTH

- Hygienic purposes
- Increase energy and relieve fatigues because since your brain is mostly water drinking it helps you to concentrate better and stay focus.
- Promote weight loss by removing by-products of fat and reduced eating intake.
- Flushes out toxin through sweat and urination which reduces the risk of kidney stones and UTI.
- Improve skin complexion by moisturizing your skin,keep it fresh,soft,glowing and get rid of wrinkles.
- Maintains regularity by aids indigestion as water is essential for digestion and to prevent constipation.

MEASURES USED TO IMPROVE WATER QUALITY

The first step to improving health is to improve the quality of the water consumed through various methods. Such as:

1. Water filtration
2. Use of Septic systems for persons living in rural communities.
3. Use of sewage plants for persons living in urban communities.
4. Use of chemical methods e.g. chlorination

WHAT CAN I DO TO IMPROVE WATER QUALITY ?

1

Manage pesticides, herbicides and fertilizer wisely.

2

Educate and involve your children

3

Recycle and reuse house goods instead of throwing them in the trash

4

Use water wisely

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6

Clean water and sanitation

Challenges

UNSAFE WATER, INADEQUATE SANITATION and **INSUFFICIENT HYGIENE** kill 3.5 million people every year

80% of **WASTEWATER** is released the environment **UNTREATED**. Degrade the environment and you destroy **NATURE'S ABILITY TO PROVIDE SAFE DRINKING WATER**

WATER SCARCITY affects more than 40% of the global population

Solutions

STOP DUMPING CHEMICALS AND WASTE into the environment, **INVEST IN SANITATION** and **RAISE AWARENESS** on best hygiene practices

PROTECT NATURAL RESOURCES and avoid water pollution

RESTORE ECOSYSTEMS to secure access to safe water

WATER POLICY AND SOCIAL JUSTICE

WATER POLICIES

- Countries like the United States of America has put in place various policies to ensure that water quality is maintained. Such as:
  - Clean Water Act
  - Safe Drinking Water Act along with others.
- In Jamaica we have National Water Policy Sector and Implementation Plan (2019).
- Jamaica follows the Safe Drinking Water and World Health organization water quality standards.
- Lots of policies were brought to the table however, they were not finalized.

CLEAN WATER ACT

- Also known as the Federal Water Pollution Control Act is the cornerstone of water quality legislation in the United States.
- The Clean Water Act consist of five separate parts, called Titles.
- **Title I** (introductory section)- declares the goals and policies of the act.According to title on the objective to this Act is to:
    - *Restore and maintain the chemical,physical and biological integrity of the Nation's water.*
- Another goal of the Clean Water Act is to make the nation's water fishable and swimmable.
- This Title also includes descriptions of research and other related progams.

CLEAN WATER ACT

Title II provides a description of the grant programs for constructing of both public and municipally owned sewage treatment plants in United States between 1972-1987.

However, in 1987 Act was amended and the grant program was phased with a revolving fund and low-interest loan program.

The loan program was administered by individual states that received federal matching funds

Title II includes a description of the river basin planning program.

CLEAN WATER ACT

- **Title III**- includes water quality standards and enforcement measures. The standards are used to judge the water quality, individual state water quality agencies typical developed and submitted to the Environmental Protection Agency for review and application.
- **Title III**- includes a description of programs for developing effluent limitations, reviewing water quality conditions, preventing the discharge of oil and hazardous substances and maintaining clean lakes.
- **Title III**- includes the procedures for reviewing or inventorying water quality conditions. Acting to the Act State agencies inventory the water quality in their state and submit a summary report to the Environmental Protection Agency. It also included the inventory of polluted water and suspected sources of contamination and describes efforts being make to improve the quality of these waters.

CLEAN WATER ACT

- **Title IV**- Contains programs for water quality permits and licenses namely:
  - National Pollutant Discharge Elimination System
  - The dredge and fill permitting plan
  - Water Quality Certification program.
- **Title V**- includes other general provision of the Act such as administrative procedures, definitions and methods of procurement. It also describe the procedures that individual citizens can take to file a civil suit against any entity, including the government, for violating the terms of the Clean Water Act.

SAFE DRINKING WATER ACT (SDWA)

- Key piece of legislation that protects drinking water.
- This Act was originally passed in Congress in 1974 to protect public health by keeping drinking water free from contamination, and it has been amended several times over the years.
- The Act defines the maximum concentrations of contaminants allowed in our drinking water. This defines the maximum concentration level for inorganic, organic and microorganisms.
- The Environmental Protection Agency sets these contaminants levels after reviewing the findings of scientific studies and evaluating public comments.
- The water is considered as being safe to drink once the concentrations of the contaminants are below the limits established.

SAFE DRINKING WATER ACT (SDWA)

- In 1986 amendments were made to the SDWA were made to include the regulation of the additional contaminants.
- The SDWA required all communities to adequately test their drinking water for the regulated contaminants.
- The Act specifically states:
  - Which contaminants must be tested and the required frequencies
  - The number of samples to be taken and the specific techniques acceptable for conducting the analyses.

Only approved laboratories can perform most the analyses required by SDWA.

SAFE DRINKING WATER ACT (SDWA)

- Regulates the testing of surface and groundwater sources for drinking water differently.
- Water providers must filter and disinfect surface water sources before delivering them to customers.
- Surface water treatment required both filtration and disinfecting while only some groundwater requires the disinfection processes because they are below the surface where pollution occurs.
- The SDWA requires commimites to review their water distribution systems to evaluate pipe materials and report due to concerns of the health effects of lead and copper.
- The public must be notified of the maximum contaminant level established in the SDWA are exceeded in a community’s drinking water supply.

THE NATIONAL WATER SECTOR POLICY AND IMPLEMENTATION ACT

- Is to manage water resources in a sustainable and integrated manner to facilitate the population having universal access to potable water and adequate sanitation by 2030 and beyond.
- It recognize access to safe water and sanitation as a basic human right which must be convenient,reliable,affordable and at established international standards for quality and quantity.

5. Standards for Access to Potable Water Supply and Improved Sanitation - The GOJ aims to ensure that all individuals across the island have access to potable water supply by 2030. This means that water supply will be safe, convenient, of sufficient quantity, reliable and affordable. Cities and major towns will have sewerage services provided by a utility company. Where sewerage service is not possible, all households will have individual access to safe and environmentally friendly sanitation solutions.

NATIONAL AMBIENT WATER QUALITY STANDARD

- “The National Ambient Water Quality Standard defines the highest quality of naturally occurring freshwater across the island, i.e. relatively unpolluted freshwater; water that is considered safe and generally suitable for the main beneficial uses and supportive of natural aquatic ecosystems. This standard takes the form of a range, as opposed to a single value for each parameter.”
- Goal is to maintain high quality water where it exists and to have targets for efforts to improve water quality where lower quality is found.
- The concentrations adopted within the standard were decided after the considerations of data from sampling sites around the island that were considered to be relatively unpolluted state.
- Used by National Water Commission to guide them in assessing both source and treated water but it is not legally binding.

NATIONAL SEWAGE EFFLUENT STANDARDS (1997) AND JAMAICA NATIONAL TRADE EFFLUENT STANDARDS (1995)

- Are standards used in the natural resource conservation and NRCA regulations.
- The parameters included in the sewage effluent standard are limited to organic,nutrients,total suspended solids ,pH and fecal coliform.
- Responsible for monitoring effluent from public sewage plants is shared between Ministry of Health and National Environmental Planning Agency.
- Operators of private treatment plants including NWC are required through discharge permit, to monitor their own effluents, including flow and report data to NEPA.
- NWC is the largest sewage operator in Jamaica and up 75% of household is not connect to the sewer.
- Both NEPA and MOH can take action against the licensees if they are non-compliant.

- Includes the parameters in the sewage effluent standard and others (heavy metals,detergents, oil and grease and phenol group).
- Industries abstracting water for their uses must have a permit from water resource authority which specifies the amount of water that may be taken and requires abstracted water quality data to be reported at least twice per year.

OTHER LEGISLATIONS

Water Resource Act 1996

Public Health Regulations 1995 and amended in 2013

National Resoruce Conservations (Wastewater and Sludge) Regulations 2013

NRCA (Permit and Licences) Amendment Regulation 2015

GAPS IN LEGISLATION

- Jamaica does not have a legally enforceable drinking water quality standards.
- Jamaica tests very few parameters contained in the ambient water quality standards.
- Water quality standards were developed in the 1980s using assumptions that are no longer applicable and methods are outdated.
- Inadequate sampling and testing and not all parameters are being monitor.
- Many of the Ministry of Health approved laboratories are not equipped to analyse many of the parameters identified in the standard (specific organics and metals). There laboratories are not capable of regularly monitoring of organic materials in Jamaica

GAPS IN RESEARCH

- Lack of updated research on the water quality island wide.
- The laboratories are not capable of measuring some of the parameters.
- Most of the water sources are not readily accessible for testing.
- There is insufficient data available on microbiological, organic, heavy metal and pesticides.
- The accuracy of the data collected by external agencies and private sources is not guaranteed.

HOW CAN WE FILL THE GAPS?

- Conduct more water quality assessment.
- Educate the public more about the benefits of clean water.
- Put more legally enforceable legislation in place.

SOCIAL JUSTICE

- Even though we are a small country known as the Land of Wood and Water many residents that inhabit rural areas are still without clean running water.
- Rural areas are suppose to have a septic system however, not everyone can afford to even build proper restroom facilities.
- Even in 2022, persons are still using pit latrine or disposing of fecal material in woodlands.
- Social Inequality.

SOCIAL JUSTICE

- Water can be relatively expensive in some areas and not properly treated.
- Water shortage
- Even though Jamaica has sewage and trade effluent standards , they omit parameters that are required in order jurisdictions.
- About half of Jamaica’s sewage treatment fails to meet legal standards.
- There is no licensed facility to receive sludge.
- There is lack of clarity on what constitutes compliance to sewage standards.
- Inadequate treated sewage is discharged into water courses.
- Inadequate public education on the implications of consuming poor drinking water.

THE SCIENCE AND THE BUSINESS

WHAT ARE THE BUSINESS OPPORTUNITIES ?

- Water purification stores
- Water testing lab
- Water delivery services
- Wastewater treatment plans
- Septic system installation

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