WATER AND HEALTH

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Table of Contents

TESTING WATER QUALITY

SAMPLE COLLECTION

Samples for metal analysis can be collected in a plastic bottle while 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 when opened. Bottles used for samples for bacteria testing should be sterilized. Dark bottles are required for analytes that breakdown in sunlight. The size of the container should be important to ensure there is enough water for testing. A common preservative used is sodium thiosulfate used to stop any chlorine reactions. Hydrochloric acid is used to preserve volatile organics from microbial activities. Most analysis requires samples to be kept cool. The cooler temperature prevents the breakdown of contaminants during transit. Documentation is critical and should include date, time and location. A chain of custody form will need to accompany the sample to indicate which analysis needs to be run, date and time collected, sample identification and who collected the sample. Samplers should keep a field notebook with contains record of any onsite analysis, observations concerning water quality, weather conditions, sampling site and anything else that is important.

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 includes changes in colour, odour, taste, and turbidity.
- **Chemical tests** involve the quantification mineral and organic substances that affect water quality. This includes pH, hardness, highly toxic chemical, and biological oxygen demand.
- **Bacteriological tests** show the presence of bacteria, characteristic of faecal pollution.

PHYSICAL TEST

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 such as: magnesium, calcium, sodium and zinc.

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. 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. Eutrophication will cause the water to have a green colour. Highly coloured water has significant effects on aquatic plants and algal growth. Light is very critical for the growth of aquatic plants and coloured water can limit the penetration of light. Thus, a highly coloured body of water could not sustain aquatic life which could lead to the long-term impairment of the ecosystem. Very high algal growth that stays suspended in a water body can prevent light penetration as well as use up the dissolved oxygen in the water body, causing a eutrophic condition that can drastically reduce all life in the water body. Rich in phytoplankton. The presence of suspends solids will increase the turbidity of the water however, if allowed to settle out the sediments will fall to the bottom of the container, and you will be able to see through the water. Another natural occurring compound that will affect the colour is tannin. Water with the tannin will look clear however, even after filtration the colour will still remain because the tannin is dissolved into the water as opposed to the suspended solids.

Red tides also known as algal bloom which is called by a built-up of algae which causes discolouration of the water body. Red tides occurs when the dinoflagellates population increases in number which leads to water discolouration. Red tides are dangerous to both aquatic organisms and human because harmful toxins are released. This can be hazardous to larger organism because of biomagnification and bioaccumulation. Fishes and other grazers may be unaffected by toxins however, the toxin will become concentrated as they consume algae. The toxin may accumulate to a level where it is poisonous in larger organisms. Diseases that may affect humans include:

- Paralytic Shellfish Poisoning (PSP)- result in respiratory failure and death within 12 hours.
- Diarrhetic Shellfish Poisoning (DSP)- results in digestive upset but which is not fatal
- Amnesic Shellfish Poisoning (ASP)- result in severe and life-threatening neurological effects.

Bioluminescence is the production and emission of light through chemical reaction by living organisms. The water will appear glowing in the dark, the most common cause of this bioluminescence are dinoflagellates. Some bioluminescent organisms produce toxin that can be harmful to both humans and marine organisms. It is a beautiful sight to see however, some of these dinoflagellates are considered highly toxic. These plankton tend to bloom in water with low oxygen, high phosphate and nitrogen.

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.

CASE STUDY

Ferry river which is located by Mandela High was initially a freshwater body because of the human activities(diverting) of fresh water for agricultural purposes the salt concentration increased because the seawater starts moving inwards to fill the space left by the diverted water. Due to the high sodium levels in the water from the Ferry River cannot be used for human consumption because this will lead to increased cardiovascular and other diseases.

EXPLANATION

High concentration may be found in some groundwater due to natural occurrence such as high water table in a coastal region. Its threat to humans is that if consumed in excess it may cause hypertension or cause complications for people with heart or kidney diseases. Elevated sodium levels in water may be an indication of either point or non-point sources of pollution or saltwater intrusion.. Point pollution sources may include: infiltration of irrigation and rainfall from rich deposits of sodium–containing minerals such as sodium chloride (salts); infiltration of leachate from landfills or industrial sites (including bauxite and alumina processing) and groundwater pollution from improperly treated sewage effluent.

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 represents the concentration of hydrogen ions in a solution. A solution can either be acid (0-6), neutral (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. A pH probe or litmus paper or pH strips can be used to determine the pH because the pH probe needs to be calibrated before use.

STEPS IN CALIBRATING A pH PROBE

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 places 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 TO TEST THE pH OF A WATER SAMPLE

1. After allowing the pH reading to settle as you have done before, take the pH reading of your sample.
2. Store the probe in storage solution or a pH 4 solution when finished measuring.

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 can be 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.

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) and alkaline- cooler colors (such as blue and green).

Litmus paper and pH strips are coated with a substance that when reacted with acid or base it causes a colour change. These are quick and simple. Litmus paper is not an accurate indicator of pH, and it does not yield numerical pH value and the paper can change colour for other reasons beside acid-base reaction. At very high or low pH values, the pH strips may not give an accurate reading. If the pH is below 0 the pH strips would not give an accurate reading since the pH strips are not designed for extreme pH.

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.

1. A technician will place a small water sample in a small bottle about the size of a canning jar.
2. The amount of dissolved oxygen is measured, and the bottle placed in a warm room for five (5) days.

3. During the five (5) days a naturally occurring bacteria is added to the bottles to start the degradation of the organic material present.

4. The dissolved oxygen present in the bottle will be used up by the bacterial during its natural processes.

5. The technician will come back at the end of the five (5) days and measure the dissolved oxygen present.

6. This method is a direct measurement of the dissolved oxygen and an 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 decrease. So therefore, dissolved oxygen and biological oxygen demand can be used to determine if the water body is safe for human consumption.

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.

TOXINS

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

CASE STUDY -BIOACCUMULATION OF MERCURY

Mercury in marine organism eg. Swordfish in Canada

EXPLANATION

Mercury is converted to methylmercury by bacteria and other process. This methylmercury will then be absorbed by fishes and become tightly bound to proteins in all fishes tissues and muscles. No method of cooking can reduce the amount of mercury. Over time the mercury concentration in body can build up and cause mercury poisoning. Methyl mercury accumulates as you move up the food chain. Methyl mercury in the water and sediment is taken up by tiny animals and phytoplankton. Smaller fishes eat large quantities of phytoplankton overtime. Larger predatory fish consume many smaller fish, accumulating methylmercury in their tissues. The older and larger the fish the greater the potential for high mercury levels in their bodies. Fish are caught and eaten by humans and animals, causing methylmercury to accumulate in their tissues. Methyl mercury is absorbed into the body six times more easily than inorganic mercury. It can migrate across the blood brain and placental barrier allowing it to react directly with the brain and fetal cell.

HOW TO TEST FOR TOXINS?

Bioassays can be used to determine the level of toxicity.

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

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

BACTERIAL TEST- 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 there 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 and is 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

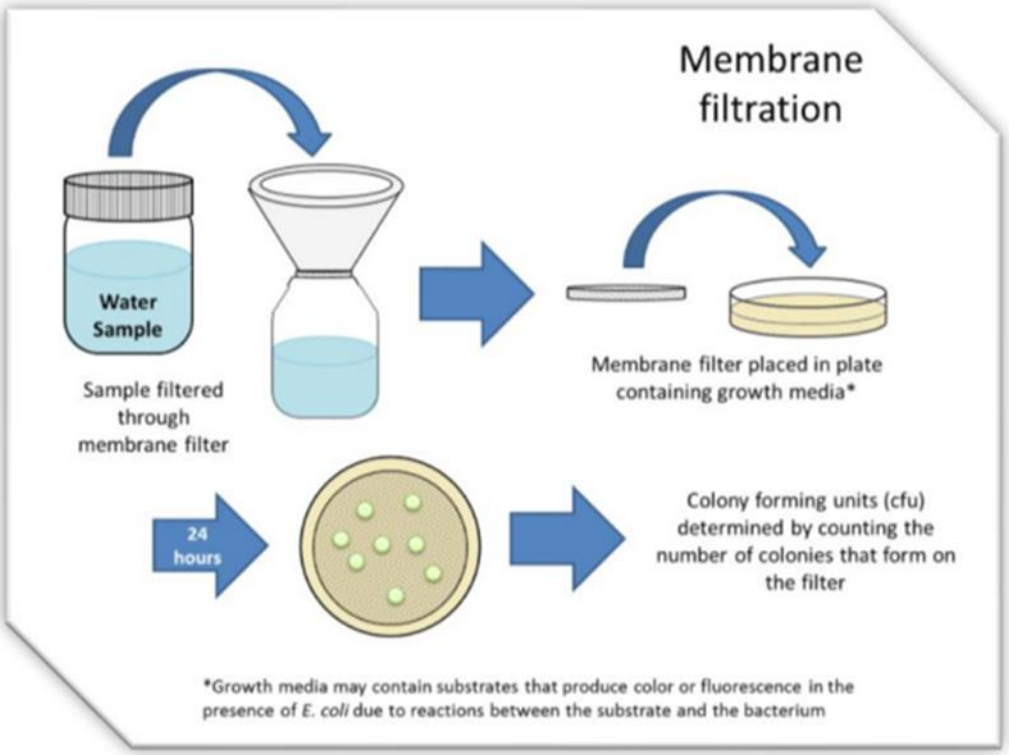

Diagram showing the membrane filtration process.

This method is typically used for low bacteria count samples. The sample is then poured through a membrane filter. The bacteria in the sample stays on the membrane filter.

That filter is then moved to a petri dish that contains nutritional broth or agar. The colony forming unit will then be determined by counting the number of colonies formed on the filter.

MULTIPLE TUBES/ MULTIPLE WELL

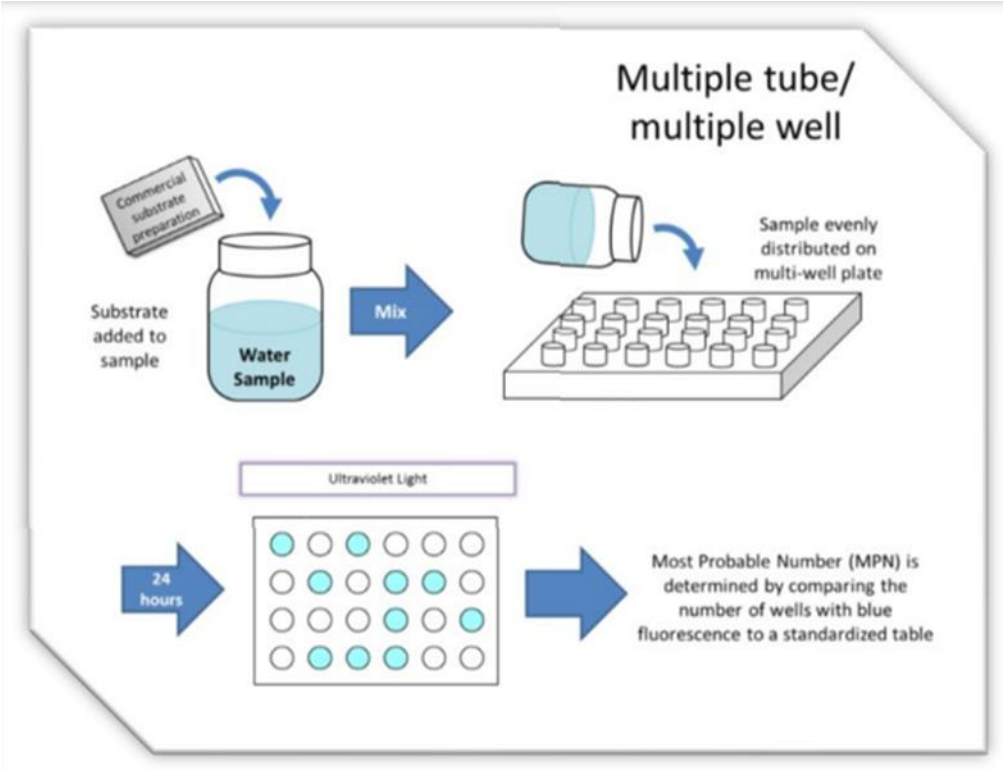

Diagram demonstrating the multiple tubes/ multiple well approach.

In the multiple tube/multiple well approach, a water sample is mixed with a commercial reagent containing methylumbelliferyl-β-glucuronide (MUG). E. coli enzymatically cleaves MUG forming a fluorescent product. Samples are distributed into a multi-well plate. After incubating for 24 hours, the MPN (most probable number) is estimated from the number of wells that are positive for the presence of bacteria growth using a standardized table. The MPN is a statistical estimate of the mean bacteria density.

MULTIPLE TUBE FERMENTATION

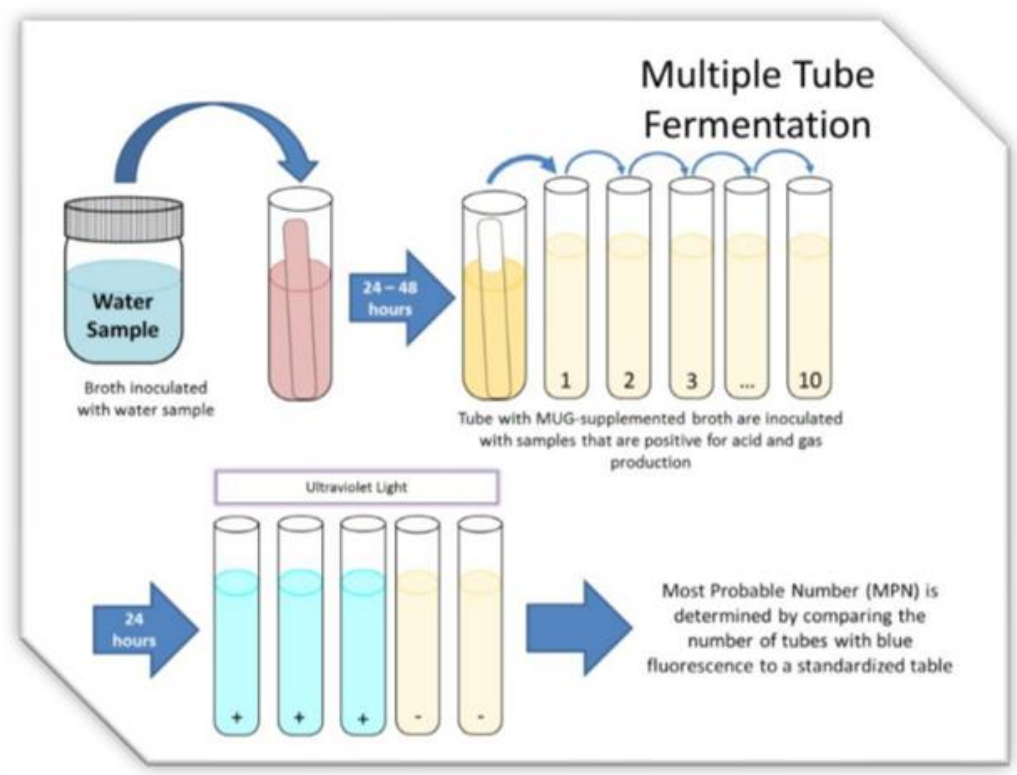

Diagram showing multiple tube fermentation

The multiple tube fermentation approach is a two-step process. First, a water sample is added to test tubes containing bacteria growth media and incubated for 24-48 hrs. Tubes that are positive for the production of acid and/or gas are then added into a series of tubes with media containing MUG. After 24 hours, the tubes are examined for fluorescence. The bacteria level is reported as the most probable number (MPN). The MPN is estimated from the number of tubes that are positive for the presence of bacteria growth using a standardized table. This approach is not used frequently as the precision is low unless a large number of samples are collected and it is more labour and time intensive than the other approaches

HOW TO INTERPRET THE RESULTS?

SAFE WATER	
• No significant evidence of bacterial contamination • Total coliforms: ≤ 5 • E. coli: 0	Even though the results show that the water is safe for consumption. Consecutive samples need to be collected 1-3 weeks to determine that the water supply quality is stable. 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 focal 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

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:

- Water filtration such as:
  - Distillation
  - Reverse Osmosis
  - Active carbon
  - Ion exchange
  - Ultraviolet filtration
- Use of septic systems for persons living in rural communities.
- Use of sewage plants for persons living in urban communities.
- Use of chemical methods e.g. chlorination

Proper water filtration not only allows for clean water but it also allows the water to be odourless and tasteless. You can choose between physical and chemical filtration. Physical filtration involves the use of a filter to sieve to remove larger impurities while chemical filtration involves passing the water through active material and this material will absorb the contaminants.

Distillation involves heating the water to its boiling point which causes the water to evaporate leaving behind the contaminants. The water vapour will the condense and cool and the pure water can be collected. This is not good for contaminants with similar or lower boiling points like water, this method is only good for heavy contaminants and bacteria. Benefits of using distillation is that it is reusable, feasible for heavy contaminants and remove a wide variety of contaminants. Distillation requires careful maintenance, large amount of energy, it is not space efficiency and water may have a flat taste.

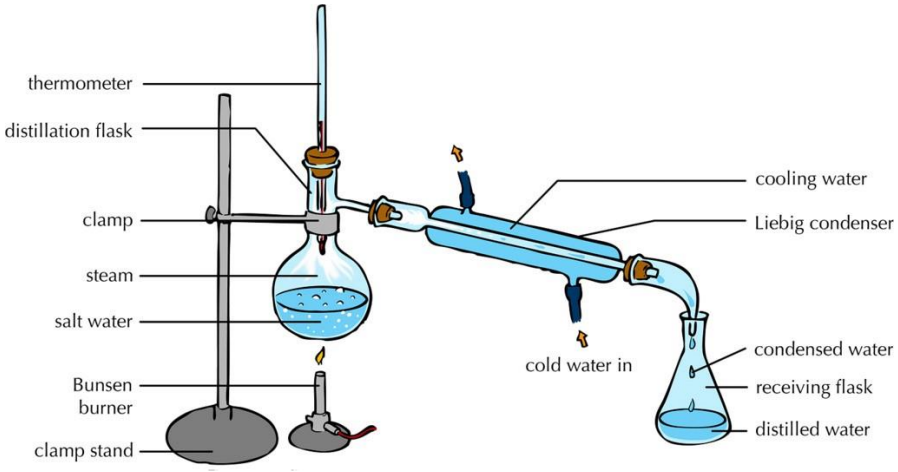

Diagram showing the process of water distillation.

Reverse osmosis involves the use of a semi-permeable membrane through which the water passes leaving the large impurities behind. This semi-permeable membrane acts like a filter through which the water moves with great pressure causing the water to move from a region of higher concentration to a region of lower concentration. Energy is needed to aid the pushing of the impure water in the natural direction, this process is powered by a pump. The salts and sugars are retained in the thin membrane. This process removed chemical contaminants such as chloride, sodium, and copper and effective in reducing substances such as sulfate and nitrates. Dissolved gases such as hydrogen sulfide, pesticides and herbicide are not removed by this process. The benefit of reverse osmosis is that it targets a wide range of contaminants while being low maintenance and it is low economical. It requires a high-pressure pump as the flow rate limits the process. It also is more efficient with a cardon filter.

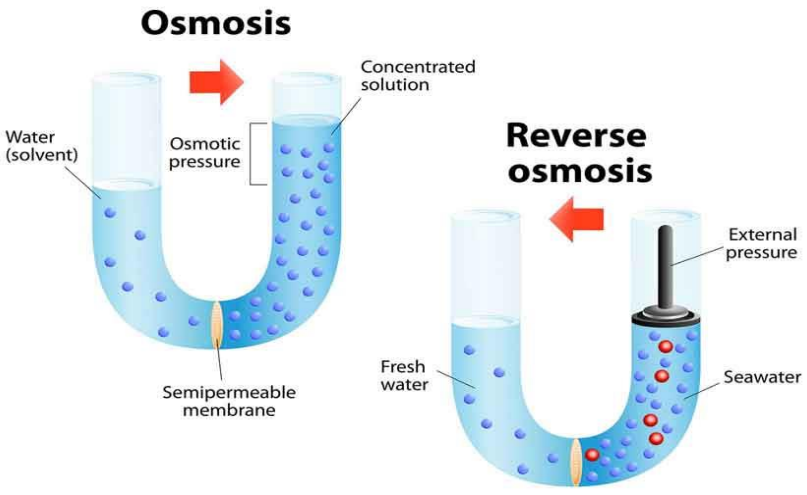

Diagram showing reverse osmosis water filtration setup

Activated carbon is often the second step after reverse osmosis, it utilizes the absorption capabilities of carbon to reduce the impurities. It removes chemical, gases and bacteria which improves the bad odour and taste. Charcoal is commonly used which is a very porous form of carbon, so it acts like a sponge. The adsorptive feature of the charcoal traps variety of impurities, this process captures liquid or gases by using solids or liquids. This method is excellent in the removal of impurities such as chlorine, some pesticides, and industrial solvents. Activated carbon doesn't not remove heavy metals such as nitrates or change the hardness of the water. The efficiency of this system is dependent on the diameter of pores, diffusion rate and adsorptions process. So therefore, its best used with other methods. The benefit of activated carbon is that it is simple to use and an excellent way to remove chlorine and other dissolved organic chemicals. The carbon filter will need to be changed when it clogs up and the correct carbon filter needs to be chosen for different impurities.

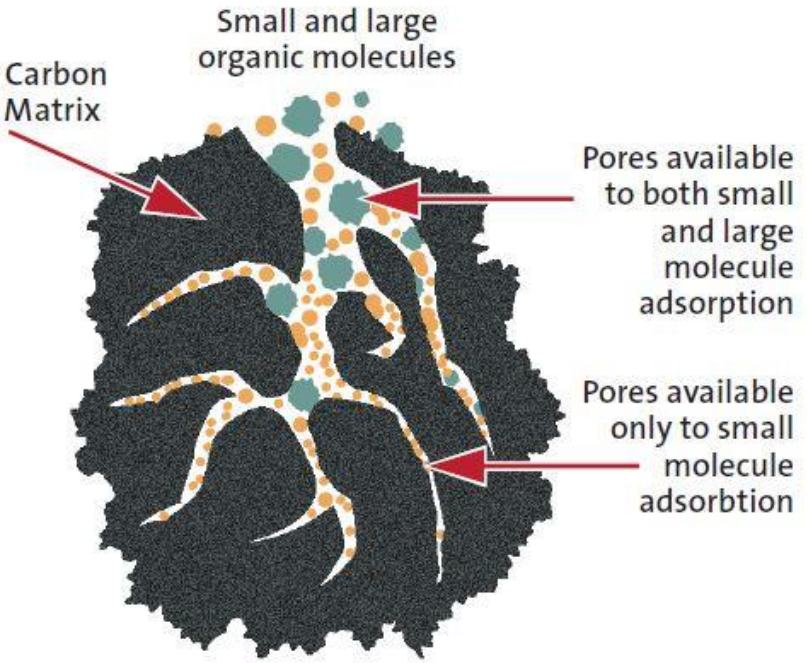

Diagram of activated carbon water treatment process

Ion exchange soften the water by splitting the atoms of any contaminants in ions by trapping the ions and releasing the purified water. The hard and impure water from reverse osmosis treated is prepared using this process. The Zeolite beads contains sodium ions which exchanges two sodium ions for every calcium or magnesium ion that is removed. Ion exchange filter splits apart compounds around it and the beads attract the calcium and magnesium. It traps all the incoming impure ions and fill the gaps by releasing its own sodium ions. Ion exchange reduces and remove the impurities to make the water softer as it replaces the contaminants with sodium. However, the water will need to go through filtration to make water potable. Ion exchange is highly effective when paired with reverse osmosis and great for the treatment of hard water. However, this water may not be great for persons with low sodium diet and the filter needs to be recharged with sodium ions.

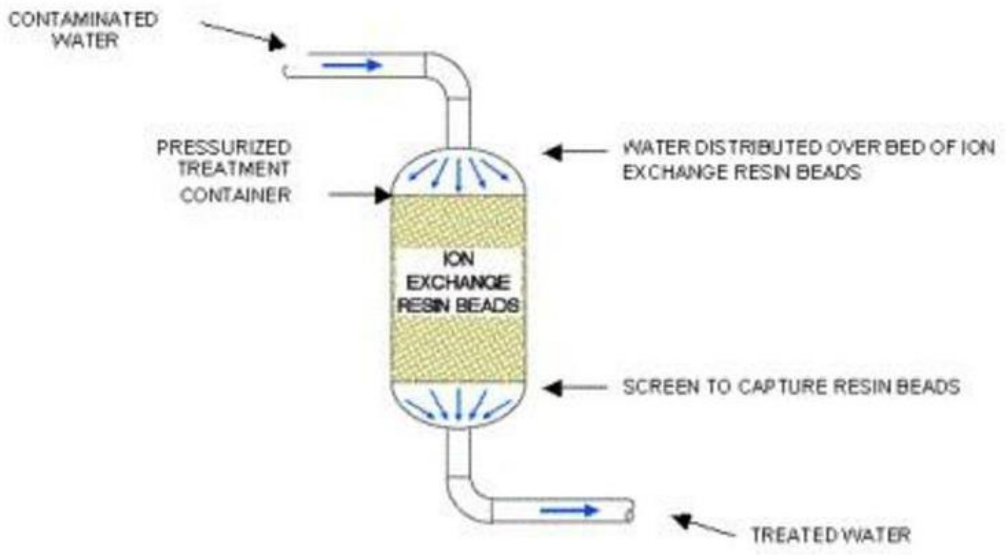

Diagram of ion exchange water treatment process

Ultraviolet filtration can be used to remove microorganisms, the water is passed through a chamber which contains a UV light that kill off any bacteria, parasites, and viruses. This method cannot remove mineral contaminants.

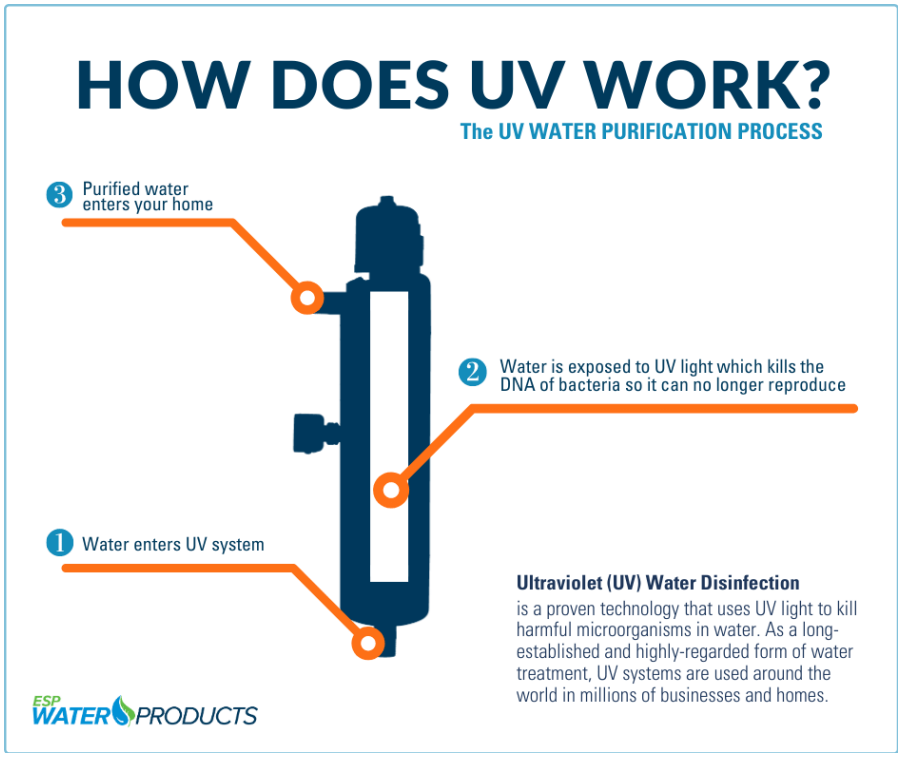

Diagram showing how the ultraviolet water treatment

We also must pay attention to the water we release into the environment as they can contaminate the groundwater supply. To improve wastewater rural areas are required to have a septic tank while urban areas are required to have sewage wastewater treatment plant. Septic tanks are underground wastewater treatment which digests organic matter then separate the oils from the solids. The effluent is discharged through a series of perforated pipes designed to slowly release the effluent into the soil. Pumps or gravity can aid the septic tank effluent to trickle through the sand or other media to remove or neutralize disease causing pathogens and other contaminants. The effluent will receive further treatment via filtrations, adsorption and biodegradation which helps to decrease the contamination of groundwater supply.

The type of sewage treatment facilities used in Jamaica are oxidative ditch, activated sludge, primary treatment, and water stabilization pond. There are four steps in the treatment of sewage such as preliminary, primary, secondary and tertiary. The preliminary stage removes the easily separated solids (rags, plastics, wood and stones) by using a screening and grit removal channels. At the primary stage the suspended solids settle through sedimentation and the grit and scum is removed. The secondary stage involves biological treatment via oxidation of settles sewage. The germs found in the wastewater is killed or removed. During the tertiary stage which is the final stage is done to improve the quality of the effluent and this is an optional step.

Chlorination is one of the methods that can be used to disinfect water because it is inexpensive and yet effective. Chlorine inactivates microorganisms by damaging its cell membrane. Chlorination can be done at any time and point throughout the water treatment process. Pre-chlorination is when chlorine is applied immediately after it enters the treatment plant. It can either be applied to raw water or added in the flash mixer for uniform dispersion. Chlorine is added to raw water to eliminate algae and other form of aquatic life so they will not affect the later stage of water treatment. Chlorination can also be done at the final stage for purification of public drinking water. Often followed by upstream filtration which moves sediments that can tie up chlorine and shield organisms from its effect. Chlorine can react with many organic compounds to form by-products that are recognize as potent carcinogens

WHAT CAN I DO TO IMPROVE WATER QUALITY?

- Manage pesticides, herbicides and fertilizer wisely.
- Educate and involve your children
- Recycle and reuse house goods instead of throwing them in the trash
- Use water wisely

WATER POLICY

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.

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 programs.

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.

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 made to improve the quality of these waters.

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 describes the procedures that individual citizens can take to file a civil suit against any entity, including the government, for violating the term.

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 of the Clean Water

Act. In 1986 amendments were made to the SDWA were made to include a regulate the additional contaminants. The SDWA required all communities to adequately tester 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. 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 communities 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 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 faecal 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.

SOCIAL JUSTICE ISSUES AND WATER

- 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 supposed 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.
- Lots of persons in today 20th century are still not educated about the importance of water quality and health. Developing countries like many places in Africa and the Caribbean does not have proper wash, sanitation, and hygiene practices. This is evident in the number of deaths caused using unclean drinking water.
- Due to water shortage, water can be relatively expensive in some areas and not properly treated.

- 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.

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