Ethiopian TVET-System

Water Supply and Sanitation Supervision

Level IV

Module Title: Select Water Treatment Requirements for Waterborne

TTLM Code: EIS WSS4 TTLM 0920v1

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This module includes the following Learning Guides

LG 43: Investigate waterborne microorganisms.

LG Code: EIS WSS4 M 10 LO1-LG-43

LG44: Identify processes to remove Microorganisms.

LG Code: EIS WSW4 M 10 LO2-LG-44

LG45: Determine appropriate water treatment Processes.

LG Code: EIS WSW4 M 10 LO3-LG-45

Instruction Sheet	Learning Guide -43 Investigate waterborne microorganisms.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying waterborne microorganisms found in water source
- Identifying general characteristics of microorganisms
- Identify water quality and Treatment problems of microorganisms
- Identifying water treatment processes for microorganisms problems
- Identifying characteristics and diseases of pathogenic microorganisms

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Identifying waterborne microorganisms found in water source
- Identifying general characteristics of microorganisms
- Identify water quality and Treatment problems of microorganisms
- Identifying water treatment processes for microorganisms
- Identifying characteristics and diseases of pathogenic microorganisms

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 4". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks 1, 2, 3 & 4" in each information sheets on pages 26, 31, 34, & 37.

5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2, & 3 on pages 38 and do the LAP Test on page 39”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
8. Then proceed to the next LG.

Information Sheet-1	Identify waterborne microorganisms found in water source

1.1. Introduction to waterborne microorganisms

Waterborne infections are caused by ingestion, airborne or contact with contaminated water by a variety of infectious agents which includes bacteria, viruses, protozoa and helminthes. Waterborne diseases are illnesses caused by microscopic organisms, like viruses and bacteria that are ingested through contaminated water or by coming in contact with feces.

Every day, hundreds of millions of people are impacted by the global water and sanitation crisis. Together, unsafe water and the inaccessibility of basic sanitation are leading contributors to extreme poverty.

Still, 841 million people woke up today without basic access to safe water. We believe the water crisis is solvable in our lifetime, and by working together, we can take one step closer to a world free from waterborne disease.

Below is the most up-to-date information from the world's top data-gathering and humanitarian organizations.

- **Water and Sanitation Crisis**:

✓ Over 579 Million Drinking Contaminated Water:

✓ 841 Without Basic Water Access

✓ Over 579 million people Worldwide are drinking unsafe water from hand-dug wells, ponds, swamps, rivers, and springs. Contaminated water causes disease and even death, especially among children.

The majority of people drinking unsafe water, approximately 81 percent, are living in rural, underserved regions of the world.

Additionally, 262 million are drinking what's classified as safe water, but they are traveling over 30 minutes to fetch it. The World Health Organization (WHO) calls this “limited” access, and it often inhibits children and their families from thriving in their communities.

Drinking unsafe water makes people sick, which costs them in health clinic fees, in productive work time, and in their educations.

Figure 1.1. Woman in Ethiopia gathers water from the village pond.

- **The Impact of the Crisis**

Along with the specter of frequent illness and death, children who do not have safe drinking water are more likely to drop out of school. Their parents, weighed down by expensive medical fees, struggle to afford tuition.

Saving money becomes nearly impossible, and families in the most rural, hard-to-reach communities find themselves selling their land and possessions to afford treatment for water-related illnesses.

Human dignity and potential is suppressed under the weight of a full container of contaminated water, and without safe water and healthy practices, poverty is passed onto the next generation.

The good news is, there's hope in our lifetime.

There are many global organizations working to end the crisis through the implementation of WASH (water access, sanitation, and hygiene) programs and the construction of safe water projects. Each year, fewer people wake up with the burden of unsafe water.

At Life water, our staff work alongside villages, visiting every home to ensure that families learn life-saving health practices and working together to engineer custom, long-lasting safe water sources for every community.

Since 2016, generous Life water donors have funded over 400 safe water projects, serving 188,766 people with clean water, health, and gospel hope. You can make an impact on the global water and sanitation crisis today. Explore villages in urgent need of help

1. Cholera

Cholera is commonly found in humanitarian emergencies or marginalized villages where poverty and poor sanitation are rampant. The disease is spread through contaminated water and causes severe dehydration and diarrhea. Cholera can be fatal within days or even hours of exposure to the bacteria, but only 1 in 10 people will develop life-threatening symptoms.

Symptoms include:

- Nausea
- Vomiting
- Diarrhea
- Muscle cramps

Prevention and Treatment

Cholera is a waterborne illness that's easily prevented when traveling. Wash your hands often, only eat foods that are completely cooked and hot (no sushi), and only eat vegetables you can peel yourself, like avocados, bananas, and oranges. Of course, drink safe water.

Figures 1.2. Life water teaches Proper hand washing in developing countries

When hand washing in unavailable, cholera can impact an entire village. In developing countries like Ethiopia, data shows that 97% of households do not have means to wash their hands properly, meaning they don't have safe water, soap, and a facility to wash. This makes hygiene management and disease prevention nearly impossible for these communities.

Life water helps prevent cholera in remote villages by teaching families how to construct their own hand washing devices. To date, 5,970 homes in Ethiopia alone have built their own hand washing station (called a "tippy tap") using locally-sourced materials.

2. **Typhoid Fever**

Although rare in industrialized countries, typhoid fever is well-known in extremely poor parts of developing nations; it's estimated that up to 20 million people worldwide suffer from the illness each year. It's spread through contaminated food, unsafe water, and poor sanitation, and it is highly contagious.

Symptoms include:

- A fever that increases gradually
- Muscle aches
- Fatigue
- Sweating
- Diarrhea or constipation

Prevention and Treatment

Vaccines are recommended for people who are traveling in areas where poor sanitation and unsafe water are common. The vaccine can be injected via a shot or taken orally for a number of days. To prevent it, refrain from drinking any water that isn't bottled and sealed, and do not eat food from villages or street vendors. Typhoid is treated with antibiotics.

3. **Giardia**

This waterborne disease is shared through contaminated water, most often in ponds and streams, but it can also be found in a town's water supply, swimming pools, and more. The infection is caused by a parasite and typically clears up after a few weeks. However, it's possible for those who have been exposed will experience intestinal problems for years to come.

- **Symptoms include:**
  - ✓ Abdominal pain
  - ✓ Cramps and bloating
  - ✓ Diarrhea
  - ✓ Nausea
  - ✓ Weight loss

Prevention and Treatment

While there is no vaccine for giardia, there are simple ways to avoid the infection. Wash your hands with soap often, don't swallow water while swimming, and drink only bottled water.

With time, the immune system will typically beat giardia on its own. But, if symptoms worsen, doctors prescribe anti-parasite and antibiotic medications.

Water-poor communities cannot protect themselves from illnesses like giardia, and treatment for this illness can come at a high cost for a family living in poverty. For these reasons, Life water's programs focus on long-term prevention. This includes constructing safe water sources and teaching health practices, one house at a time, until the entire community has the resources and the knowledge to prevent waterborne illness.

Figures 1.3. Certificated Health home in Ethiopia

When families learn how to construct their own hand washing facilities, bathrooms, and dish drying racks, they take control of their health. They check off a list of basic health practices, and they become certified Life water "Healthy Homes."

4. **Dysentery**

An intestinal infection, dysentery is a waterborne disease characterized by severe diarrhea as well as blood or mucus in the stool. Dysentery is good reason to always wash your hands, as the disease is spread mainly through poor hygiene. It can be caused by bacteria, viruses, or parasites in unsafe food and water and by people coming in contact with fecal matter. If someone experiencing dysentery cannot replace fluids quickly enough, their life could be at risk.

- **Symptoms include:**
  - ✓ Stomach cramps and pain
  - ✓ Diarrhea
  - ✓ Fever
  - ✓ Nausea
  - ✓ Vomiting
  - ✓ Dehydration

Prevention and Treatment

To prevent dysentery, wash your hands with soap frequently, order all drinks without ice, don't eat food sold by street vendors, and only eat fruits you can peel. Drink only sealed, bottled water while traveling in places with higher dysentery risk, such as communities where proper hygiene practices are uncommon.

Mild dysentery usually clears up with rest and fluids, but over-the-counter medications such as Pepto-Bismol can help with stomach cramping. More severe cases can be treated with antibiotics, although some strains of the disease are resistant.

5. **Escherichia Coli (E. coli)**

E. coli is a bacteria with various strains, some dangerous and some beneficial. For example, E. coli bacteria are important in creating a healthy intestinal tract.

However, if animal waste has found its way into farmland where produce is grown or if strains of E. coli are spread through the process of making ground beef, those who consume these foods could experience symptoms of the waterborne illness. The bacteria are also found in unsafe water sources around the globe where human water sources and cattle coexist.

Symptoms of dangerous strains of E. coli are similar to that of dysentery and other waterborne diseases. Most bouts of E. coli pass within a week, but older people and young children have a greater chance of developing life-threatening symptoms. Anyone believed to have been exposed to contaminated food or water should contact a doctor if diarrhea contains blood.

Prevention and Treatment

As always, avoid water possibly contaminated by human and/or animal feces (like ponds, rivers, and swamps). If you are going to eat ground beef, cook thoroughly. Wash fruits and vegetables well, wash hands often, and drink only safe water.

To treat the disease, drink plenty of safe water, rest, and take over-the-counter diarrheal medication.

While these are simple prevention and treatment tips, there are many remote communities in Uganda who have no choice but to drink from swamps.

Figure 1.4. A woman and her child gather water from the swamp in Uganda

Life water staff is serving the village of Kikomera Biri, Uganda, where families gather water from a swamp. The results of water testing showed an extremely high risk for dangerous pathogens like typhoid, harmful strains of E. coli, and other waterborne diseases. Unless this community—which is already experiencing extreme poverty—pays for a taxi to drive into town for expensive, bottled water, they have no choice but to keep drinking from the swamp.

Thankfully, a new safe water source for all 299 residents is planned for construction this year.

6. Hepatitis A

Hepatitis A is a liver infection caused by consuming contaminated food and water or by coming in close contact with someone who has the infection. People who travel in developing countries often or work in rural communities with poor sanitation and hygiene management are most exposed to the disease.

- **Symptoms include:**
  - ✓ Fatigue
  - ✓ Clay-colored bowel movements
  - ✓ Jaundice
  - ✓ Nausea and vomiting
  - ✓ Abdominal pain, especially near your liver
  - ✓ Loss of appetite
  - ✓ Sudden fever

The infection usually goes away in a few weeks, but it's possible that it can become severe and last several months.

Prevention and Treatment

The best way to prevent hepatitis A is by getting the vaccine. Eat only foods that are thoroughly cooked and served hot, and avoid eating anything at room temperature. Only eat fruit that you can peel and that you have peeled yourself. Don't eat from food vendors and don't eat runny eggs or raw/rare meat. For a full list of dos and don'ts, visit the CDC's page on Hepatitis A.

Once a person has hepatitis A, they build an immunity and will likely never get it again. However, the symptoms are serious, often forcing people to take time off work or school to recover. If you have contracted hepatitis A, rest, avoid drinking alcohol, and drink plenty of fluids. The disease will run its course, and full recovery is expected after three months.

7. **Salmonella**

Most cases of salmonella come from ingesting food or water contaminated with feces. Undercooked meat, egg products, fruits, and vegetables can also carry the disease. Most people don't develop complications, but children, pregnant women, older adults, and people with weakened immune systems are most at risk.

- **Symptoms include:**
  - ✓ Blood in stool
  - ✓ Chills
  - ✓ Headache
  - ✓ Diarrhea

Prevention and Treatment

When preparing your own food, make sure to cook thoroughly and store or freeze within 30 minutes of use. Avoid touching birds or reptiles, and as always, wash your hands frequently.

Salmonella infection dehydrates the body. Treat it by drinking fluids and electrolytes. More serious infections can require hospitalization and antibiotics.

Prevent Waterborne Diseases for Good: Give with Lifewater

There are many parts in the world where waterborne diseases are rampant, deadly, and knowledge about prevention is not widely available. For over 40 years, Lifewater has sought out these places, working with communities to teach vital sanitation and health practices and constructing custom water technologies in places where water access is most difficult.

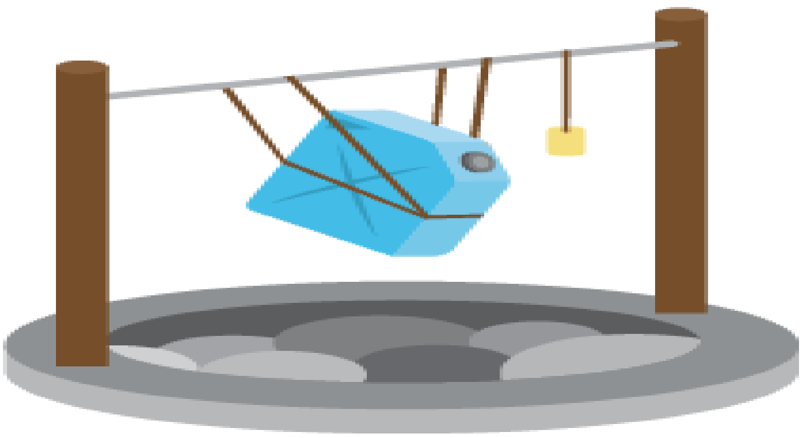
Over and over again, cholera is prevented and typhoid eradicated. Children no longer battle waterborne illness, and parents go back to work.

Figure 1.5. Life water staff member greets a village resident in Cambodia

When you become a monthly giving partner with Lifewater, you give safe water to one person for life every month. Or, give one time. Every gift changes lives. You'll receive real-time updates on progress and photos to share with friends and family. You can eliminate waterborne diseases for good. Give today.

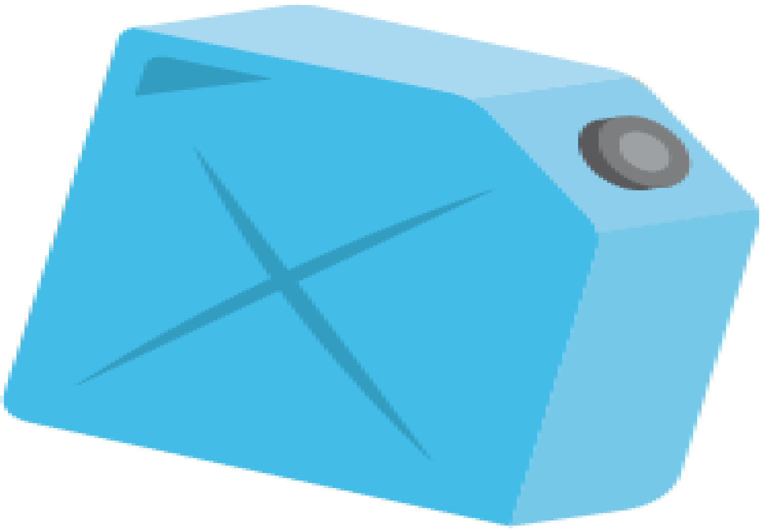
- **Healthy Home Requirements**
    - ✓ **Hand washing**

Washing hands with soap stops the spread of disease. Every household builds simple hand washing devices with local materials.



✓ **Safe Water Storage**

Clean water stored in dirty containers becomes contaminated water. Families learn to keep water safe from collection to consumption



✓ **Drying Rack**

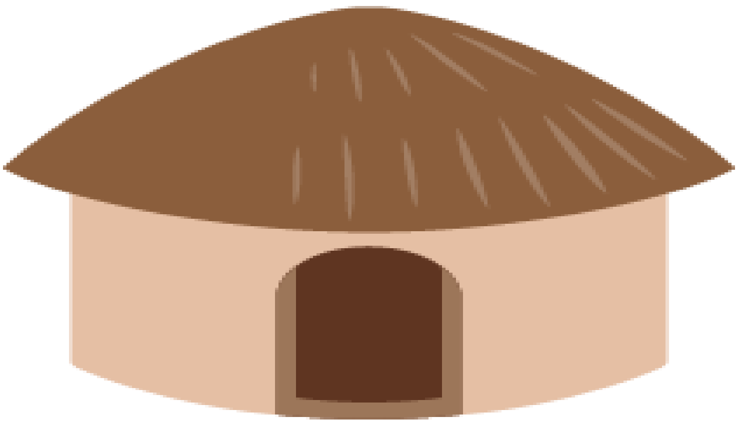
Washing dishes and drying them in the sun, away from animals, helps stop the spread of harmful pathogens.

- ✓ **Latrines**

Building and using a simple pit or pour-flush latrine separates people from poop, drastically decreasing waterborne diseases. It also provides safety and dignity.

- ✓ **Clean Compound**

Keeping the household environment clear of trash and feces discourages germs, keeps people safer, and helps them take more pride in their home



- ✓ **Certification**

When a household demonstrates all these elements, it is awarded a “Healthy Home Certificate,” which is displayed proudly as a symbol of accomplishment.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each

1. Hepatitis A is a liver infection caused by consuming contaminated food and water or by coming in close contact with someone who has the infection.

   A. True.   B. false

2. Keeping the household environment clear of trash and feces discourages germs, keeps people safer, and helps them take more pride in their home

   A. Clean Compound
   B. Safe Water Storage
   C. Drying Rack
   D. All.

3. Clean water stored in dirty containers becomes contaminated water. Families learn to keep water safe from collection to consumption

   A. Clean Compound
   B. Safe Water Storage
   C. Drying Rack
   D. All

4. Hepatitis A Symptoms include

   A. Vomiting
   B. Abdominal pain, especially near your liver
   C. Loss of appetite
   D. Al

5. Giardia is waterborne disease is shared through contaminated water, most often in ponds and streams, but it can also be found in a town's water supply, swimming pools, and more

   A. True   B. False.

Note: **Satisfactory rating - 10 points and above   Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 1

Score = ___________

Rating: ____________

Name: ___________________________

Date: ________________

1. ________________
2. ________________
3. ________________
4. ________________   5. ________________

Information Sheet-2	Identifying general characteristics of microorganisms

2.1. Introduction to microorganisms

Microorganisms or microbes are microscopic organisms that exist as unicellular, multicellular, or cell clusters. Microorganisms are widespread in nature and are beneficial to life, but some can cause serious harm. They can be divided into six major types: bacteria, archaea, fungi, protozoa, algae, and viruses. The vast majority of microbes on the earth pose no real threat to humans, plants or animals; in fact they actually work alongside humans to make world go round, aiding decomposition, decay and even helping us to digest our food. However, there are some microorganisms which negatively impact our lives, causing illness, bad odours and damaging products and surfaces

Bacteria, perhaps the most well-known microorganism, are a member of the prokaryotes; they have no nucleus within the cell and contain no organelles (specialised cellular 'organs'). Within bacteria there are two classes, Gram positive bacteria which have thicker cell wall and Gram negatives which have a thinner layer sandwiched between an inner and outer membrane.

Bacteria are extremely diverse and in terms of number are by far the most successful organism on Earth. Bacteria are the only microorganisms which can live harmlessly within the human body, often aiding bodily functions such as digestion. In fact there are more bacterial cells within the human body than humans cells, albeit much smaller in size.

Bacteria, of all the 'living' microorganisms, cause the most problems in terms of disease in humans, despite only relatively few bacteria being dangerous.

Fungi are eukaryotes which mean they have a defined nucleus and organelles. The cells are larger than prokaryotes such as bacteria. Fungal colonies can be visible to the human eye once they have achieved a certain level of growth, for example mould on bread. Fungi can be split into three main groups,

- ✓ Moulds which display thread-like (filamentous) growth and multicellular structures,
- ✓ Yeasts which are typically non-filamentous and can be single celled and
- ✓ Mushrooms which possess a fruiting body for production of spores.

Fungi can be problematic for the immune compromised and contain significant pathogens which can cause disease in plants. However, we also recognize organisms from this group from widespread use in the food industry, for production of beer and other foodstuffs.

Viruses are considered by many experts to not be living organisms. They essentially consist of nucleic acid (DNA or RNA,) and a protein coat. A virion (a virus particle) requires a host cell in order to replicate. Within the human anatomy a virus enters a human cell and hijacks the it, using the cell to replicate.

In many cases the immune system detects the presence of the virus and takes action leaving us with the symptoms of a common cold or influenza. Some viruses can cause permanent and irreversible damage to cells, for example HIV.

Algae are a more difficult to define group of organisms, containing both prokaryotes and eukaryotes by some definitions. Unlike other microorganisms algae are typically photosyn thesisers and are typically found in marine environments. Prokaryotic algae, or Cyanobacteria, are often called blue-green algae although some definition or opinions will state that algae are eukaryotes only (that they are essentially small aquatic plants).

2.2. characteristics of microorganisms

Microorganisms are the smallest organisms on Earth. In fact, the term microorganism literally means "microscopic organism." Microorganisms may be composed of prokaryotic or eukaryotic cells, and they may be single-celled or multicellular. Examples of microorganisms include algae, fungi, protozoa, bacteria and viruses.

This assignment will explain how the structures and characteristics of microorganisms are used to classify them. It will illustrate the structures of microorganisms observed using a light microscope and an oil immersion lens. Also will include the comparison of the characteristics of microscopes used for classification and include the comparison of the use of different microscopy technique to observe the structures of microorganisms. Finally it will evaluate the use of microscopy technique to observe structures and classify microorganisms.

Bacteria

Bacteria are prokaryotic, made up of one cell. Nearly all bacteria are couple micrometers in length. Bacteria have features such as ribosomes which make proteins from mRNA. Flagellums are hair like structure that turns around to make the bacteria move, some bacteria have additional flagellums or none. Cell wall gives the cell strength and structure. The cell membrane has folds called mesosmes. Plasmids are small loops of DNA, plasmids are not in all bacteria cells. The main DNA floats free in the bacteria cell, the long strand is called a bacterial chromosome. A few bacteria have short hair like features called pili. Pili is used in gene transmission as the pili help the bacteria cell stick to another bacteria cell

How are bacteria classified?

Bacterial classification uses binomial nomenclature two names genus and species. Species can be divided into subspecies because some organisms are too related to each other. Species of bacteria have different variations called serotypes which determine their structure.

There are five different groups that bacteria can be classified in to, these are spirochaetes, bacilli, vibrios, Spirilla and cocci, from their shapes.

- ✓ Spirochaetes- corkscrew
- ✓ Bacilli- rod shaped
- ✓ Vibrios- comma
- ✓ Spirilla- helical
- ✓ Cocci- spherical

The different groups of bacteria can live by themselves or in groups.

- ✓ Scientific Classification
- ✓ Domain: Prokaryotes.
- ✓ Kingdom: Bacteria.
- ✓ Phylum: Firmicutes.
- ✓ Class: Bacilli.

- ✓ Order: Lactobacillales.
- ✓ Family: Streptococcaceae.
- ✓ Genus: Streptococcus.
- ✓ Species: Streptococcus pyogenes.

- **Gram Staining**

Gram Staining can help to further classify bacteria. By grouping bacteria into two groups' gram negative and gram positive based on their cell wall. Gram negative is shown when the cell wall of the bacteria don't keep the crystal violet satin used in the gram staining process. The gram positive is when the cell wall of the bacteria keep the crystal violet satin.

- **Bacilli**

Bacilli is a group of bacteria, which are rod shaped and are gram positive. Species of bacillus form spores in conditions that bacteria don't grow in. These endospores make this group of bacteria resistant to chemicals and heat. A few bacillus bacteria can harm plants, humans and other microorganisms

An example is B. cereus can cause canned food to go bad, and if eaten can cause food poisoning for a short while.

- **Cocci**

Cocci is a group of bacteria, which is spherical in shape and are gram positive. Species of cocci can be used to help in identification. If two cocci cells are present they are called diplococci, more than eight of cocci cells are called staphylococci. Some are arranged like squares or in clusters this is because the reproduction of bacteria affects this.

- **Spirilla**

Spirillum is a group of bacteria, which is helical shaped and are gram negative.

- **Vibrios**

Vibrio is a group of bacteria, which is comma shaped and are gram negative. Species of vibrios are very mobile and don't need oxygen, and have up to three flagella at one end.

- **Spirochaetes**

Spirochete is a group of bacteria, which are corkscrew shaped, very mobile and is not classified as gram positive or gram negative. This type of bacteria have harmful pathogens which cause diseases such as Lyme disease.

- **Why are bacteria classified?**

Bacteria are classified as it helps professionals who are working with bacteria day to day. A microbiologist at a hospital may want to know which treatment is needed for a patient. A scientist working with cultures might want to know if his strategy is working or not. A hygienist may want to check if the food plant he is looking after contains any harmful microorganisms.

- **Why are bacteria important in medicine?**

Bacteria for a long time have been used to make bacteria vaccinations and the discovery of antibacterial antibiotics, since this bacterial diseases have gone down.

To make these bacteria vaccinations the toxin protein that bacteria make, toxin protein is made inactive, so it will not cause disease.

People with weak immune systems will need to have top up vaccinations if having the inactive vaccination to make sure they can fight the disease

- **Why are bacteria important in the industry?**

Ethanol can be made by using yeast. Yeast have enzymes that in the process of yeast fermentation, the enzymes turn carbohydrates such as sucrose into simple sugars like glucose, then it converts them into ethanol and carbon dioxide.

- **Why are bacteria important in food?**

Bacteria can convert milk in to other products that are widely consumed, such as yoghurt and cheese. Buttermilk is used using a culture of Lactococcus bacteria, yoghurt are made the same way but using a different culture of bacteria. Most cheese are allowed to ripen with the use of microorganisms, this is important because different types of bacteria give the cheese different tastes and textures. To preserve food bacteria fermentation is used for pickled onions, pickled gherkins and olives.

- **Viruses**

Viruses are microorganisms which are nucleic acid surrounded by protein. They are smaller than bacteria. Viruses have features such as containing a center of DNA or RNA. The protein coat around the DNA is called the capsid, some viruses have an extra layer called an envelope, taken from the cell membrane of a previous host cell. Attachment proteins stick out from the edge of the capsid or envelope. These lets viruses attach itself on to a host cell. Some viruses carry proteins inside their capsid.

- **How are viruses classified?**

Viruses are classified by their shape and size. Also chemical composition and how they replicate.

Mode of Replication: The genome of a virus may contain RNA or DNA which maybe single stranded (ss) or double stranded (ds) linear or circle. The genome may occupy either one nucleic acid molecule (monopartite genome) or several nucleic acid segments (multipartite genome). The different types of genome require different replication strategies.

- **Why are viruses classified?**

Viruses don't share the same classification system as organisms because they are not believed to be living. Viruses do not have metabolism which means they can't produce their own food and can only reproduce using an infected host cell.

- **Why are viruses important in medicine?**

Majority of vaccinations use weakened viruses, this is because if a non-weakened virus was used it would reproduce rapidly inside the body, but by using a weakened virus there is small chance for it to infect the person with the disease rather than preventing it. Weakened viruses only reproduce usually 10-20 times compared with a non-weakened virus, which reproduces thousands of times when a person is infected. Because weakened viruses reproduce less, it means it still can produce memory B cells for that particular infection for the future.

- **Why are viruses important in the industry?**

Viruses benefit plants for example there are few plants grow in the hot soils surrounding the geysers and Yellowstone National Park. This plant has a relationship that a fungus takes over the plant and a virus then infects the fungus. This happens to make the plant survive in 50 degrees Celsius. (U.S. Department of the Interior 2017)

- **Fungi**

Fungi are eukaryotic they can be unicellular or multicellular. These are heterotrophs, which means they feed on decaying organic matter. The features that are within a fungi cell are a nucleus where DNA is wrapped around proteins, some have free floating loops of DNA called plasmids, this is similar to bacteria cells.

The cells further contain mitochondria which is said to be the power house of a cell, Golgi apparatus is also present in the cell, and endoplasmic reticulum which is seen as the worm shaped. The cell wall of the fungi cell has polysaccharides called chitin and glucans, which gives it rigid layers and prevents the cell wall from losing moisture and protection. Also have plasma membrane.

- **How is fungi classified?**

There are four different groups that fungi can be classified in which are Chytridiomycota, Zygomycota, Ascomycota and the Basidiomycota. They are classified into these groups depending on how they reproduce.

- ✓ Chytridiomycota- chytrids
- ✓ Zygomycota- bread moalds
- ✓ Ascomycota- yeast and sac fungi
- ✓ Basidiomycota- club fungi

(CC BY: Attribution 2018)

Scientific Classification

- ✓ Domain: Eukaryote
- ✓ Kingdom: Fungi
- ✓ Class: Basidio Mycetes
- ✓ Order: Agric Ales
- ✓ Family: Agricac Eae

- ✓ Genus: Agaricus
- ✓ Species: Agaricus Campestris L

- **Chytridiomycota**

Chytridiomycota is the most simple of all types of fungi. Nearly all chytrids have chitin in the cell was but a group has chitin and cellulose in the cell wall. A few chytrids are multicellular but majority are unicellular. They reproduce as diploid and gametes cells that have a flagellum to help them move.

- **Zygomycota**

Zygomycetes are the smallest group of fungi, this type of fungi is the fungi that grown on the surface of breads, vegetables and fruit commonly known as mold. They are present on decaying organic matter.

- **Ascomycota**

Ascomycota are the biggest group of fungi, they are used in the industry to make different types of alcohol such as wine and beer and yeast in baking. A certain fungi can cause harm to patients who have AIDS who have a weakened immune system. They also can be harmful to crops which then are not able to eat.

- **Basidiomycota**

Basidomycota is a group of fungi which are seen as mushrooms that we eat and the bark on trees, this group includes the most edible fungi but some are very dangerous as they make toxins. For example Crptococcus neformans cause bad respiratory illnesses. (CC BY: Attribution 2018)

- **Why is fungi classified?**

Fungi classification have changed over the years, once they were just thought to be plants but now they have their own kingdom and are in fact more related to animals that plants.

- **Why is fungi important in medicine?**

Fungi are useful to humans they are a part of the nutrient cycle in ecosystems. Fungi can naturally produce antibiotics and stop the growth of bacteria, meaning they don't have to compete in nature. Penicillin a well-known antibiotic that can be made separating from fungi. After someone has an organ transplant they are likely to reject the organ but a drug called cyclosporine lowers down the risk of rejection. Also a fungi called ergot alkaloids is used to stop bleeding in hospital. (Boundless Biology 2018)

- **Why are fungi important in the industry?**

The farming industry uses fungi in the root system, this because without in they would not live. Fungal supplements are used as soil additives that can be bought from gardening stores. It is mostly favored for organic farming.

- **Why are fungi important in food?**

Fungi makes up a lot of the human diet such as cheeses the fungi penicillium ripens them, also mushroom the most common one found in many dishes is the meadow mushroom. Truffles are used to garnish dishes and are very expensive. For the making of blue cheese, sheep milk is stacked to get the molds of the genus penicillium for the blue veins and strong taste of the cheese. Fungi is used to ferment wheat to make beer and fruit to make wine. Saccharomyces cerevisiae is an example of yeast that is used in baking. It has been used for thousands of years to make bread which was a staple in people's diets. They did this by leaving dough to gather yeast from surrounding air for a couple of days.

- **Protozoa**

Protozoa are eukaryotes which are singled celled. They are parasitic that feed on decaying matter. Protozoa can have many shapes due to not having a cell wall. Some protozoa will have features such as a rigid shell and pellicle which is a thick membrane. They come in all different shapes and sizes. The size range is big with 10 micrometers as the smallest and 60 micrometer. The largest protozoa are called xenophyophores, which can measure up to 20 centimeters in diameter. (Wikimedia Foundation, Inc 2018)

- **How is protozoa classified?**

Protozoa the group has thousands of species, which belong to kingdom Protista. Some protozoan feed on bacteria and algae others are parasites.

They are classified into four groups based on how they move:

- ✓ Amoebiod
- ✓ Flagllates

- ✓ Cilliates
- ✓ Sporozoans

- **Amoebiod**

Amoebiods are a group of protozoa that can change its shape, which are in dirt or mud and in water. They travel by using pseudopods, which are located on the edge of the amoebiod, they also use pseudopods to submerge their prey. Amoebiod feed in many different ways.

- **Flagllates**

Flagellates are a group of protozoa that have a flagella on the end of it. They live in many ways one is as parasitic, in intestines or bloodstream of host, the host does not benefit from this relationship. Some flagellates are autotrophic while others are heterotrophs.

- **Ciliates**

The ciliates are a group of protozoans that have hair-like organelles called cilia. Cilia are used in the movement, eating and attaching. Most ciliates are heterotrophs.

Several ciliates feed by osmotrophy which is by absorbing the energy. Whereas some hunt for their sources of energy that are other protozoa

There are different types of ciliate protozoa which are crawling, stalked and swimming ciliates. All of which use ciliates for movement and getting their food.

- **Sporozoans**

Sporozoans are a group of protozoa that are unicellular and consist of parasites.

Why are protozoans important in medicine?

Protozoans are food for a lot of organisms that live in water. Example Zooplankton are small protozoans that live in the sea. This is a part of the diet of blue whales, they consume this as they are taking gulps of water.

- **Why are protozoans important in the industry?**

Protozoans have vital roles with soil fertility. As protozoa eat the bacteria in soil, they keep the number of bacteria low, which would mean a higher fertility of soil. They also produce nitrogen and phosphorus which benefits the soil. As plants such as lentils like to thrive in nitrogen and phosphorus rich soil.

Table 2.1. Summary of microorganisms (Pete Jago 2013)

	Bacteria	Viruses	Fungi	Protozoan
Cell Structure	No nucleus Complex cell wall	dependent on host cell	Nucleus Simple cell wall	Nucleus Cilia Flagella
Reproduction	Binary Fission (asexual)	Replication (asexual)	Budding Fragmentation Spore release (sexual/asexual)	Binary Fission (asexual)
Structure	Spherical Rods Spirals	Spherical/ Polyhedral Helical	Spherical (oval) Filaments	Complex Structure
Size	1-3 µm	-0.01-0.3 µm	3-30 µm	1-150 µm

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page.

Instruction I: Choose the best answer for the following question (2pts each)

1. Microorganisms are widespread in nature and are beneficial to life, but some can cause serious harm.

   A. True. B. false.

2. Fungi are eukaryotes which mean they have a defined nucleus and organelles

   A. True. B. false.

3. Fungi can be split into three main groups,

   A. moulds which display thread-like (filamentous) growth and multicellular structures,

   B. Yeasts which are typically non-filamentous and can be single celled and

   C. Mushrooms which possess a fruiting body for production of spores. D. all

4. Amoeboid are a group of protozoa that can change its shape, which are in dirt or mud and in water. A. True. B. false.

Note: **Satisfactory rating - 6 points and above Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 2

Score = ___________

Rating: ____________

Name: ___________________________

Date: ________________

1. _______, 2.________,3 __________, 4.__________

3.1 Introduction to water quality

The term water quality is generally used to describe the microbiological, physical and chemical properties of water that determine the fitness for use of a specific water source. Even though water may be clear, it does not necessarily mean that it is safe for us to drink. It is important to judge the safety of water by taking the following three types of parameters in to consideration.

- **Physical quality**:

Refers to water quality properties (such as conductivity, pH and turbidity) that may be determined by physical methods. The physical quality mainly affects the aesthetic quality (taste, odour and appearance) of water.

- **Chemical quality**:

Refers to the nature and concentration of dissolved substances (such as organic and inorganic chemicals including metals and non-metallic ions.). Many chemicals in water are essential as part of a person's daily nutritional requirements, but unfortunately above a certain concentration most chemicals (e.g. zinc, copper, manganese) may have negative health effects if they are beyond the recommended values of WHO and National water quality guidelines.

- **Microbiological quality**:

Refers to the presence of organisms that cannot be individually seen by the naked eye, such as protozoa, bacteria and viruses. Many of these microbes are associated with the transmission of infectious water-borne diseases such as gastroenteritis and cholera.

- **Common Physical testing parameters**

The physical characteristics of drinking water are usually things that we can measure with our own senses: turbidity, color, taste, odor and temperature. In general, we judge drinking water to have good physical qualities if it is clear, tastes good, has no smell and is cool.

✓ **Color:**

The color of water is due to dissolved or colloidal materials like iron, manganese , clay, silt……

- ✓ **Taste/odor**:

Taste/odor of water is typically treated by aeration. Aeration is a process of releasing dissolved gases from raw water by exposing to the air.

- ✓ **Turbidity:**

Turbidity is a property that is a result of particles of solid matter being suspended in water, rather than dissolved into it. If water is turbid it appears to be cloudy, so is a visual guide to water quality. Turbidity of water can be tested in the laboratory using a device of turbidity meter. The result of turbidity of as sample is described in a unit of NTU (Nephlometric Turbidity Unit). The WHO Guideline for turbidity in drinking water is less than 5 NTU.

Fig.2.2 Turbidity meter

Turbidity tubes:

Turbidity tubes are another easy and cheap way to visually estimate the turbidity of water.

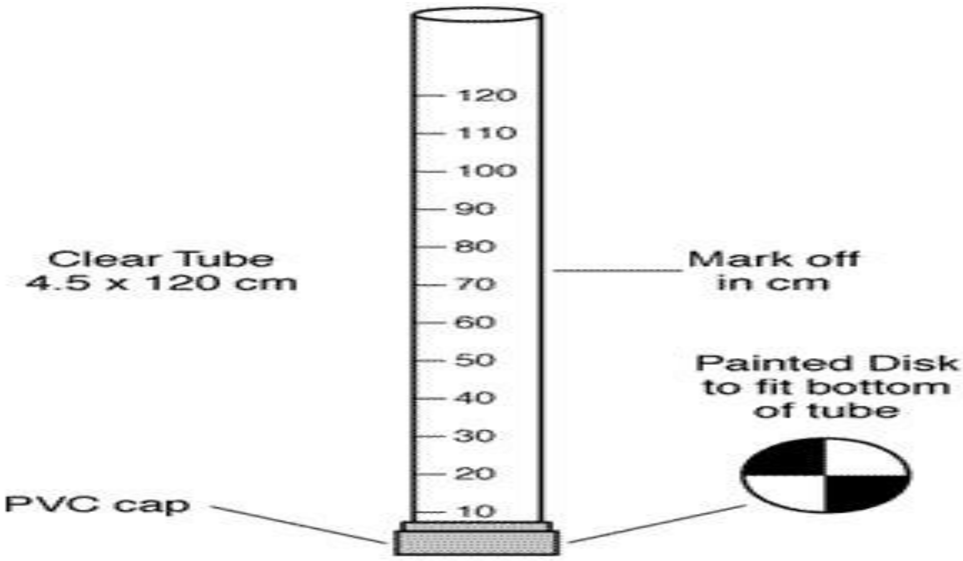


Fig.2.3. Turbidity tube

✓ **Temperature:**

Is a physical property of water showing how the water is hot or cold. The temperature of water can be measured using an instrument called thermometer. Thermometer can be found in the market in different designs and marks.

3.2. Common Chemical Parameters for Testing

Some of the most common chemical parameters for testing include:

- **p^H**:

Is a way of expressing the hydrogen-ion concentration of a solution? It is a measure of how acidic or alkaline the water is on a scale 0 to 14. Pure distilled water is neutral with a pH value of 7. p^H measurement below 7 indicates the solution is acidic containing more H^+ ions than OH^- ions. Measurement of pH 7above indicates that the reverse situation exists making the water alkaline. P^H meter is a device used to measure the p^H values of a sample of water.

- **Total Dissolved Solids (TDS):**

Total dissolved solids (TDS) contained in water are made up of inorganic salts (mainly sodiumchloride, calcium, magnesium, and potassium) and small amounts of organic matter that are dissolved in water Total dissolved solids of a sample of water can be measured in the laboratory using a device of **TDS** meter.

- **Electrical Conductivity (EC):**

Electrical conductivity (EC) of a substance is defined as its ability to conduct or transmit electricity through it. The presence of chemicals (such as calcium and magnesium ions) gives water the ability to conduct electricity. Testing for EC does not give specific information about the types of chemicals present in water, but it gives an estimation of total dissolved solids (TDS). Thus, the EC of water is an indirect measure of dissolved chemicals.

- **Fluoride, F^-** :

.Owing to the universal presence of fluorides in the earth's crust, all water contains fluorides in varying concentrations. The bulk of the water normally available to humans is involved in the hydrological cycle, which means that it originates in the sea. Traces of fluorides are present in many waters; higher concentrations are often associated with underground sources.High concentrations of fluoride in water causes dental mottling and flourosis.

- **Iron: Fe^{+2}**:

Iron is found in most natural waters and can be present in several forms, namely in true solutions as collide or in a suspension as visible particles; or as a complex with other mineral or organic substances.

- **Hardness**:

in water is due primarily to calcium and magnesium carbonates and bicarbonates (carbonate hardness that can be temporarily removed by heating) and calcium sulfate, calcium chloride, magnesium sulfate, and magnesium chloride (noncarbonated or permanent hardness that cannot be removed by heating). The sum of carbonate and non-carbonated hardness is total hardness, expressed as calcium carbonate.

- **Manganese:**

Manganese can be naturally found in groundwater and surface water, and it usually occurs with iron. However, human activities may also be responsible for manganese contamination in water in some areas. Water with high levels of suspended manganese usually has a black color or black flakes in it.

- **Dissolved oxygen:**

Dissolved oxygen (DO) is a measure of the quantity of free oxygen molecules dissolved in water. The concentration of DO is an important indicator of the health of an aquatic ecosystem because oxygen is essential for almost all forms of life. Oxygen is necessary for respiration and for some chemical reactions. Ongoing low dissolved oxygen in a water body will harm most aquatic life, because there will not be enough to sustain life. DO of water or waste water can be measured using a device of DO meter.

Biological characteristics:

Also called bacteriological characteristics. These include bacteria, virus, protozoa and worms. They cause *waterbone_diseases*. Generally microorganisms in water are classified as *coliforms*. Two types of coliforms are there in water- *total coliform* and *fecal coliforms*.Total coliforms are collection of all microorganisms (both harmful and harmless). Fecal coliforms are harmful ones. They are measured in water by the method called *membrane filtration.*

In this method sample of water is filtered by a membrane (filter paper) with pore size 0.45µm (micrometer) and put in a dish with growth media and incubated for 14 to16 hours. For total coliform temperature of incubator is set at 37^{O}C and for fecal coliform at 44^{O}C.

- **Calibration of testing equipment's**

In order to determine whether a product meets the customer requirements, measurements are often performed. To ensure that these measurements are reliable, they must be traceable to the results. The only way to ensure traceable results is to use calibrated measurement instruments. It is therefore that many quality systems as the ISO/IEC 9000 series and ISO/IEC

17025 require that instruments are regularly calibrated, in other words has to be included in a calibration system.

Calibration is the process of comparing a reading on one piece of equipment or system, with another piece of equipment that has been calibrated and referenced a set of parameters

3.2. Water Treatment problems of microorganisms

- ✓ Energy consumptions is one of the biggest **issues** confronting wastewater plants.
- ✓ Staffing shortages. Like many other industries, wastewater treatment plants also face the **problem** of a staffing shortage.
- ✓ Environmental footprint.
- ✓ Looking for new water treatment systems.

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each)

1. The term water quality **not** is generally used to describe the microbiological, physical and chemical properties of water that determine the fitness for use of specific water source A. True. B. false.
2. Refers to water quality properties (such as conductivity, pH and turbidity) that may be determined by physical methods A. True. B. false
3. Refers to the nature and concentration of dissolved substances (such as organic and inorganic chemicals including metals and non-metallic ions.).
   A. Chemical quality
   B. Turbidity
   C. Microbiological quality:
   D. All.
4. Refers to the presence of organisms that cannot be individually seen by the naked eye, such as protozoa, bacteria and viruses
   A. Chemical quality
   B. Turbidity
   C. Microbiological quality:
   D. All.
5. is a property that is a result of particles of solid matter being suspended in water, rather than dissolved into it
   A. Chemical quality
   B. Turbidity
   C. Microbiological quality:
   D. All.

***Note:* Satisfactory rating - 6 points and above Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 3

Name: ____________________________

Date: ________________

Score = ___________

Rating: ____________

2. _______, 2.__________,3 ___________, 4.___________ .5.___________

Information Sheet-4	water treatment processes for microorganisms problems

4.1. Introduction to water treatment processes

Water contains several chemical and biological contaminants that must be removed efficiently in order to produce drinking water that is safe and aesthetically pleasing to the consumer. The chemical contaminants include nitrate, heavy metals, radionuclides, pesticides, pharmaceuticals, hormonally active chemicals, and other xenobiotic. The finished product must also be free of microbial pathogens and parasites, turbidity, color, taste, and odor

To achieve this goal, raw water (surface water or groundwater) is subjected to a series of physicochemical and biological treatment processes that will be described in detail. Disinfection alone is sometimes sufficient if the raw water originates from a protected source. More commonly, a multi-barrier approach is taken to produce drinking water. Disinfection is combined with coagulation, flocculation, and filtration. Additional treatments to remove specific compounds may include pre-aeration and activated carbon treatment. The treatment train depends on the quality of the source water under consideration.

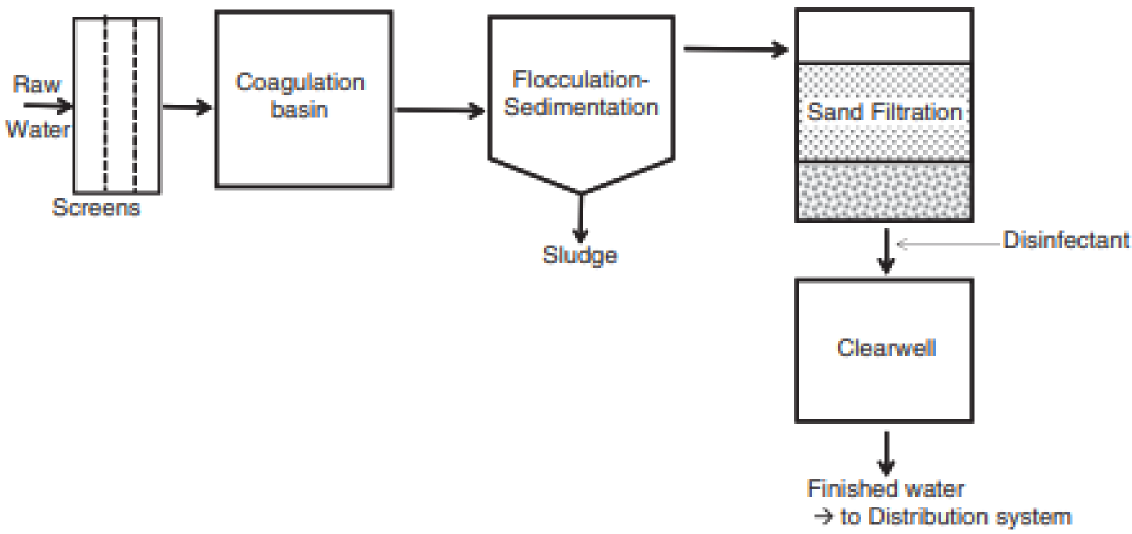


Figure 4.1. Flow diagram of a conventional drinking water filtration plant.

There are two main categories of water treatment plants: Conventional filter plants: The leading processes in this type of plant are coagulation/flocculation and filtration (Figure 2.3). The raw water is rapidly mixed with aluminum-based or iron-based coagulants. The most used coagulants are aluminum sulfate called alum $Al_2(SO_4)_3.14.3\ H_2O$, ferric sulfate $Fe_2(SO_4)_3$ or ferric chloride $FeCl_3.6\ H_2O$. Sometimes, coagulant aids are required to improve floc settling and strength. They are also synthetic high molecular weight polymers which are commercially available as anionic, cationic, or nonionic polymers. Sometimes, these polymers can be used as primary coagulants. Polyelectrolyte addition leads to less sludge which can be easily dewatered (Hammer and Hammer, 2008). After coagulation, the produced flocs are allowed to settle in a clarifier. Clarified effluents are then passed through sand or diatomaceous earth filters. Water is finally disinfected before distribution. Softening plants: The leading process in these plants is water softening, which helps remove hardness due to the presence of Ca and Mg in water, and results in the formation of Ca and Mg precipitates. After settling of the precipitates, the water is filtered and disinfected.

4.2. Process microbiology and fate of pathogens and parasites in water treatment plants

In water treatment plants, microbial pathogens and parasites can be physically removed by processes such as coagulation, precipitation, filtration, and adsorption, or they can be inactivated by disinfection or by the high pH resulting from water softening

There are several types of pathogens and parasites of most concern in drinking water

- **Viruses:**

They are occasionally detected in drinking water from conventional water treatment plants that meet the microbiological standard currently used to judge drinking water safety and treatment efficiency (Bitton et al., 1986). For example, entero viruses were detected at levels ranging from 3 to 20 viruses per 1000 L, in finished drinking water from water treatment plants that included prechlorination, flocculation, sedimentation, sand filtration, ozonation, and final chlorination (Payment et al., 1989; Payment, 1989)

- Cryptosporidium and Giardia lamblia:

The methodology for concentrating and detecting these parasites has been developed but the skill to routinely monitor their presence in drinking water is not yet available in most water treatment plants.

- Opportunistic pathogens:

These are waterborne pathogens (e.g., Pseudomonas, Alcaligenes, Acinetobacter, and Flavo bacterium species), which cause secondary infections in hospitals, particularly among immune compromised consumers. Legionella: This bacterial pathogen is an example of a non-enteric microorganism that can be transmitted by inhalation of drinking water aerosols from shower heads or humidifiers. Nosocomial (i.e., hospital-acquired) Legionnaires' disease may be contracted by exposure to Legionella from the water distribution system in hospitals (Best et al., 1984).

Several unit processes and operations are used in water treatment plants to produce microbiologically and chemically safe drinking water. The extent of treatment depends on the source of raw water, with surface waters generally requiring more treatment than is needed for ground waters. The unit processes designed for water treatment, with the exception of the disinfection step, do not address specifically the destruction or removal of parasites or bacterial and viral pathogens.

4.3. Pretreatment of Source Water:

Pretreatment is a range of steps that are designed to improve the quality of the source water prior to entry in the water treatment plant:

4.2.1. Storage of Raw Water (Off-Stream Reservoirs).

Raw water can be stored in reservoirs to minimize fluctuations in water quality. Storage can affect the microbiological water quality which is affected by physical (e.g., settling of solids, evaporation, gas exchange with atmosphere), chemical (e.g., oxidation-reduction, hydrolysis, photolysis), and biological processes (e.g., nutrient cycling, biodegradation, pathogen decay) (Oskam, 1995). The reduction of pathogens, parasites, and indicator microorganisms during storage is variable and is influenced by a number of factors, such as temperature, sunlight, sedimentation, and biological adverse phenomena such as predation, antagonism, and lytic action of bacterial phages. Temperature is a significant factor controlling pathogen survival in reservoirs. It appears that, under optimal conditions, water storage in reservoirs can lead to approximately 1- to 2-log reduction of bacterial and viral pathogens although higher reductions have been observed. Protozoan cysts are removed by entrapment into suspended solids followed by settling into the sediments.

- **Roughing Filters**.

Roughing filters contain coarse media (gravel, rocks) which help reduce water turbidity and bacterial concentrations (approximately 1-log reduction).

- **River Bank Filtration**

RBF is the seepage of water through the bank of a river or lake to the production well of the water treatment plant. RBF involves physical, chemical, and biological processes. This practice provides certain advantages such as removal of pathogens and parasites, removal of algal cells, reduction in turbidity and natural organic matter (NOM), and dilution with groundwater. Particle removal is due to the combined effect of adsorption, straining, and biodegradation. RBF decreases the concentration of assimilable organic carbon (AOC)

- **Pre- chlorination**.

A pre- chlorination step is sometimes included to improve unit processes performance (e.g., filtration, coagulation–flocculation), oxidize color-producing substances such as humic acids and help in the precipitation of iron and manganese. Although pre- chlorination reduces somewhat the levels of pathogenic microorganisms, its use may lead to increased chances of forming disinfection by-products.

- **Coagulation-Flocculation-Sedimentation**

Coagulation involves the destabilization and inter-particle collisions of colloidal particles (e.g., mineral colloids, microbial cells, virus particles) by coagulants (Al and Fe salts) and sometimes by coagulant aids (e.g., activated silica, bentonite, polyelectrolytes, starch).

The most common coagulants are alum (Al sulfate), ferric chloride, and ferrous and ferric sulfate. For example, Al2(SO4)3 (alum) precipitates as insoluble Al(OH)3 (Al hydroxide) and forms flocs that remove turbidity and microbial contaminants (Percival et al., 2000). Have suggested the potential use of bioflocculants such as the extracellular polysaccharide from Klebsiella terrigena for water treatment (Ghosh et al., 2009) but their use in water treatment plants needs further research. The process of inter-particle contacts and formation of larger particles is called flocculation. After mixing, the colloidal particles form flocs which are large enough to allow rapid settling

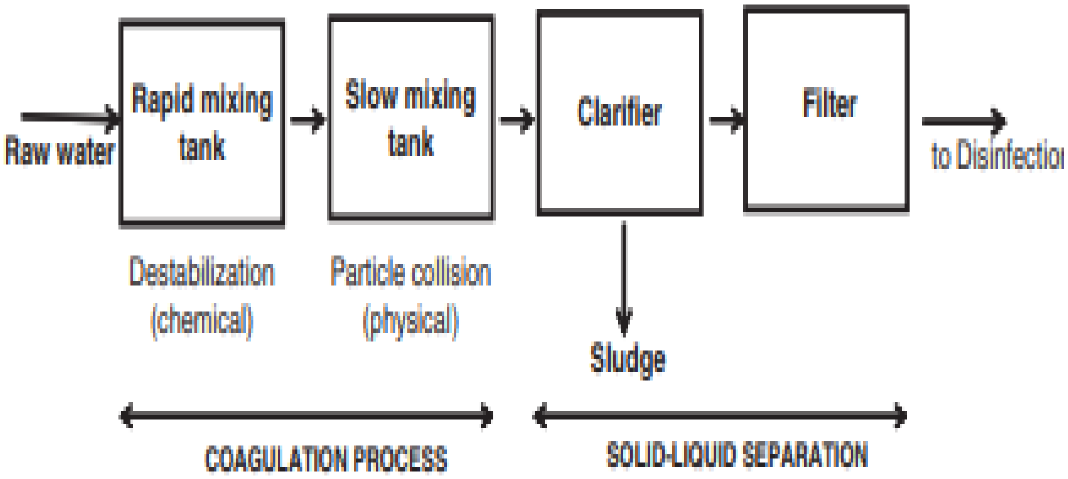


Figure 4.2. Coagulation-Flocculation-Sedimentation

- **Water Softening**

Water softening was suggested as a water treatment process in the mid-1700s by Francis Home of Scotland, and the first successful water softening plants was built in 1897 in Winnipeg, Canada (Symons, 2006). Hardness is caused by the presence of calcium and magnesium in the water.

There are two categories of hardness: carbonate hardness which is due to bicarbonates of Ca and Mg, and non-carbonate hardness which is due to Ca and Mg chlorides. Hardness is responsible for increased soap consumption and scale formation in pipes. Water softening is the removal of Ca and Mg hardness by the lime-soda process or by ion-exchange resins. The lime-soda process consists of adding hydrated lime (calcium hydroxide) or the less expensive quick lime (CaO) to the water.

Softening helps in the removal of NOM by calcium carbonate and magnesium hydroxide. The decrease in NOM will lead to lowering the formation of halogenated by-products in drinking water

The high pH (>11) generated by water softening with lime leads to an effective inactivation of bacterial and viral pathogens.

Microbial removal during water softening is due to (1) microbial inactivation at detrimental high pH values (pH ≥ 11) by the loss of structural integrity or inactivation of essential enzymes and

(2) physical removal of microorganisms by adsorption to positively charged magnesium hydroxide flocs ($CaCO_3$ precipitates are negatively charged and do not adsorb microorganisms).

As regard ion-exchange resins, Ca and Mg are removed from water by exchange with Na present on the exchange sites on the resin. Viruses are removed by anion exchange resins but not as much by cation exchange resins. However, ion-exchange resins cannot be relied upon to remove microbial pathogens.

- **Filtration**

Filtration is defined as the passage of fluids through porous media to remove turbidity (suspended solids, such as clays, silt particles, microbial cells) and flocculated particles. Filtration may include slow and rapid sand filtration, diatomaceous earth filtration, direct filtration, membrane filtration, or cartridge filtration. This process depends on the filter medium, concentration, and type of solids to be filtered out, and the operation of the filter.

- **Disinfection**

Disinfection is the last barrier against the entry of pathogens and parasites into our drinking water. Disinfection addresses specifically the inactivation of disease-causing organisms.

4.2.2. Waste residuals from water treatment plants

Water treatment plants generate liquid (e.g., filter backwash water, sedimentation tanks wash water, brine) and solid (e.g., sludges, sloughed off biofilms). These residuals harbor pathogens and parasites and may contribute to disease outbreaks. Hence, they must be disposed of properly. The liquid residuals are disposed of via direct discharge to surface waters, indirect discharge into sanitary sewers, underground injection, or land disposal. The solid residuals are disposed of via solid waste and hazardous wastes landfills, land application, or incineration

- **Drinking water quality at the consumer's tap**

Drinking water quality at the consumer's tap is affected by the service lines, indoor plumbing, and the home devices occasionally installed by the consumer to improve taste and odor problems. Water quality indoors is not covered by U.S. EPA regulations except for the Lead and Copper Rule (LCR) dealing with Pb and Cu monitoring at the tap.

- **Effect of Service Lines and Indoor Plumbing on Drinking Water Quality**

In addition to water distribution pipes, service lines and house plumbing system can also influence the microbiological and chemical quality of drinking water

Depending on the distance of the home to the water treatment plant, a flushing time of at least 2–10 minutes is necessary to lower bacterial numbers to background levels. Similarly, lead and copper concentrations were high in the first flush and decreased to background levels within 2 minutes of flushing

Table.4.1. Removal/inactivation range of bacteria, viruses, and protozoa at various water treatment plants for large communities

Pretreatment			
Roughing filters	Bacteria	0.2–2.3	Depends on filter medium and coagulant
Storage reservoirs	Bacteria Protozoa	0.7–2.2 1.4–2.3	Residence time >40 days Residence time >160 days
Bank filtration	Bacteria Viruses Protozoa	2 to >6 2.1–8.3 1–>2	Depends on travel distance, soil type, pumping rate, pH, and ionic strength
Coagulation–Flocculation–Sedimentation			
Conventional clarification	Bacteria Viruses Protozoa	0.2–2 0.1–3.4 1–2	Depends on coagulation conditions
High rate clarification	Protozoa	>2 to 2.8	Depends on blanket polymer
Dissolved air flotation	Protozoa	0.6–2.6	Depends on coagulant dose
Lime softening	Bacteria Viruses Protozoa	1–4 2–4 0–2	Depends on pH and settling time

Filtration			
Granular high rate filtration	Bacteria Viruses Protozoa	0.2–4.4 0–3.5 0.4–3.3	Depends on filter media and coagulation pretreatment
Slow sand filtration	Bacteria Viruses Protozoa	2–6 0.25–4 0.3 to >5	Depends on grain size, flow rate, pH, temperature and presence of Schmutzdecke
Precoat filtration	Bacteria Viruses Protozoa	0.2–2.3 1–1.7 3–6.7	Depends on Chem. Pretreatment If filter cake is present Depends on media grade and filtration ratet
Membrane filtration (microfiltration, ultrafiltration, nanofiltration, reverse osmosis)	Bacteria Viruses Protozoa	1 to >7 <1 to >6.5 2.3 to >7	Varies with pore size, integrity of filter medium, and resistance to chemical and biological degradation

Source: Adapted from WHO (2011a). Guidelines for Drinking-Water Quality. 4th Ed. World HealthOrganization,http://www.who.int/water_sanitation_health/publications/2011/dwq_ guidelines/en/.

- **Point-of-Use Devices for Indoor Water Treatment**

Household water treatment comprises technologies, devices, or methods to treat water at the household or at point-of-use (POU) in schools, hospitals, and other facilities (WHO, 2011b). The public at large is interested in POU home devices to remove microbial pathogens and parasites as well as toxic chemicals, and improve the aesthetic quality of drinking water (removal of taste and odor, turbidity, color). POU devices are particularly useful in rural areas not served by centralized systems and their use is increasingly being considered by consumers.

The contaminants of concern are pathogenic bacteria, viruses, protozoan cysts (e.g., Giardia), and toxic metals (e.g., cadmium, mercury, lead, arsenic, iron, manganese, organic substances of potential health significance, particulates, color, odor, and chlorine taste

Treatment is accomplished by filtration, adsorption, ion exchange, reverse osmosis, distillation, or UV irradiation.

The most frequently used process is filtration through activated carbon. POU devices may be installed in a home as faucet add-on units consisting of small activated carbon cartridges, in-line devices (filters, reverse osmosis units) that are installed under the kitchen sink or pour-through pitchers with an activated carbon filter. There are also point-of-entry (POE) devices for treating the entire home water supply. However, there are some problems associated with the use of activated carbon-based filters. Heterotrophic bacteria and, possibly, pathogenic microorganisms, colonize the activated carbon surface, leading to the occurrence of high bacterial levels in the product water. It is thus advisable to flush the unit for 1–3 minutes prior to use in the morning or after returning from vacation.

Table4.2. processes involved in point of use and in point of entry

Process	Contaminant(s) Removed
Adsorption (activated carbon)	Chlorine
Mechanical filtration	Particulates, color, turbidity, asbestos fibers, cysts, and oocysts
Reverse osmosis	Total dissolved solids, metals, nitrate, bacteria, viruses, cysts, and oocysts
Water softening (cationic)	Ca, Mg, Fe, Mn, Ba, Ra
Water softening (anionic)	Sulfate, nitrate, bicarbonate, chloride, arsenic
Distillation	Inorganics, dissolved solids, organics
Disinfection (chemical or UV)	Bacteria, viruses, cysts, and oocysts

Source: Adapted from D.J. Reasoner (2002). In: Encyclopedia of Environmental Microbiology, Gabriel Bitton, editor-in-chief, Wiley-Interscience, N.Y., pp. 1563–1575.

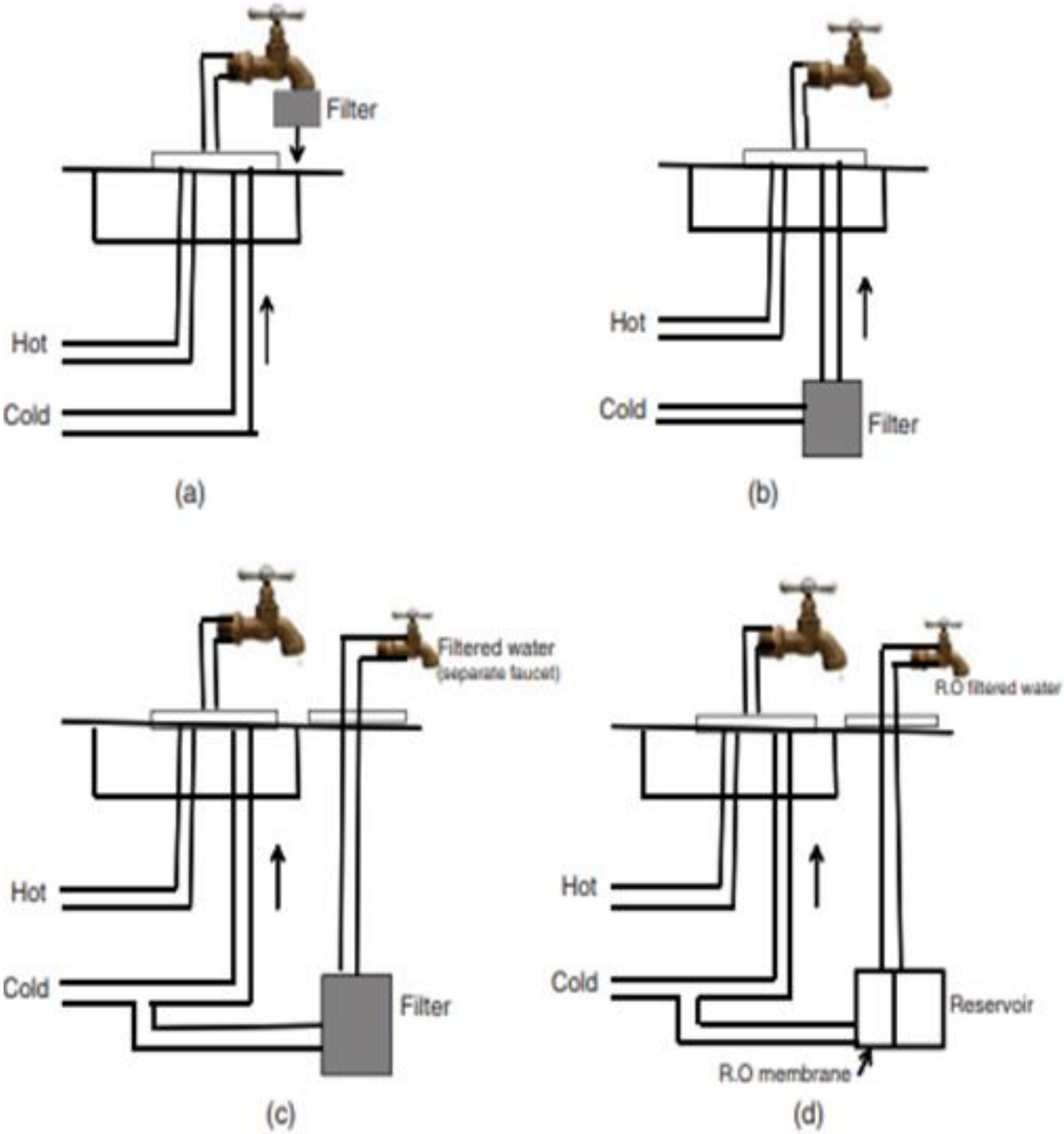


Figure 4.3. Drinking water quality at the consumer taps Point of use devices installation:

(a) faucet add on filter, (b). Under sink unit: cold water line: (c). under sink unit: cold water line bypass to separate faucet: (d). reverse osmosis cold water bypass with reservoir faucet.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each)

1. In water treatment plants, microbial pathogens and parasites can be physically removed by processes such as coagulation, precipitation, filtration, and adsorption,
   A. True. B. False.

2. Pretreatment is a range of steps that are designed to improve the quality of the source water prior to entry in the water treatment plant:
   A. True B. false.

3. Roughing filters contain coarse media (gravel, rocks) which help reduce water turbidity and bacterial concentrations (approximately 1-log reduction).
   A. True. B. false.

4. River Bank Filtration (RBF) involves
   A. Physical processes.
   B. Chemical processes.
   C. Biological processes.
   D. All.

5. The most common coagulants are
   A. alum (Al sulfate),
   B. ferric chloride,
   C. ferrous and ferric sulfate
   D. All.

6. The process of inter-particle contacts and formation of larger particles is called
   A. Flocculation.
   B. River Bank Filtration
   C. Pre- chlorination.
   D. Water Softening

7. Filtration process is depends on the
   A. filter medium,
   B. Concentration
   C. the operation of the filter.
   D. All.

1 *Note:* **Satisfactory rating - 10 points Unsatisfactory - below 10 points**

Answer Sheet 4

Score = ___________

Rating: ____________

Name: _________________________

Date: _______________

1._____, 2. _______, 3. _______, 4. ______5, ______6. . ______7, ______

5.1. Characteristics and diseases of pathogenic microorganisms

Pathogen is another word for a germ. Basically, it means any organism that can get into our bodies and make us ill. They include viruses, bacteria and fungi and there is a vast number of varieties. They are also evolving quickly, meaning new strains and species are emerging all the time. Thankfully, our immune systems are effective at protecting us from the vast majority of pathogens we encounter

Pathogens can cause a number of diseases that range in severity and how they're transmitted. Let's look at some of the diseases caused by the different types of pathogens

- **Viruses**

Viruses can cause a number of infections, many of which are contagious. Examples of viral diseases include:

- ✓ common cold
- ✓ flu
- ✓ meningitis
- ✓ warts, including genital warts
- ✓ oral and genital herpes
- ✓ chickenpox/shingles
- ✓ measles
- ✓ viral gastroenteritis, including norovirus and rotavirus
- ✓ hepatitis A, B, C, D, E
- ✓ yellow fever
- ✓ dengue fever

- **Bacteria**

Here are some examples of bacterial infections:

- ✓ strep throat
- ✓ urinary tract infection (UTI)
- ✓ bacterial gastroenteritis, such as salmonella food poisoning or E.coli infection
- ✓ bacterial meningitis
- ✓ Lyme disease
- ✓ tuberculosis
- ✓ gonorrhea
- ✓ cellulitis

- **Fungi**

Some examples of common fungal infections are:

- ✓ vaginal yeast infections
- ✓ thrush
- ✓ ringworm
- ✓ athlete’s foot
- ✓ jock itch
- ✓ fungal nail infections (onychomycosis)

- **Parasites**

Some examples of diseases caused by parasites include:

- ✓ giardiasis
- ✓ trichomoniasis
- ✓ malaria

- ✓ toxoplasmosis
- ✓ intestinal worms
- ✓ pubic lice

The following are ways that you can protect yourself and others against pathogens.

- ✓ Wash your hands often.
- ✓ Get vaccinated and ensure vaccinations are up to date.
- ✓ Prepare, cook, and store meat and other foods properly.
- ✓ Stay home when you're sick, especially if you have a fever or diarrhea, or are vomiting.
- ✓ Don't share personal items, such as razors or toothbrushes.
- ✓ Don't share drinking glasses or utensils.
- ✓ Protect against insect bites.
- ✓ Practice safe sex.
- ✓ Travel wisely by getting informed about health risks and special vaccinations.

Pathogens have the ability to make us sick, but when healthy, our bodies can defend against pathogens and the illnesses they cause.

Treatments are available for many of the illnesses caused by the different types of pathogens. There is also symptom relief for those that can't be treated, such as some viral infections.

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each)

1. Pathogen is another word for a germ. Basically, it means any organism that can get into our bodies and make us ill.
   A. True. B. false.

2. Viruses can cause a number of infections, many of which are **not** contagious. Examples of viral diseases include:
   A. common cold
   B. flu,
   C. hepatitis A, B, C, D, E
   D. None
3. Here are some examples of bacterial infections:
   A. bacterial gastroenteritis,
   B. bacterial meningitis
   C. tuberculosis
   D. All.
4. Which of the following is **not** examples of common fungal infections are:
   A. ring worm
   B. athlete's foot
   C. Fungal nail infections.
   D. None
5. Which of the following Some examples of diseases caused by parasites include:
   A. giardiasis
   B. malaria
   C. intestinal worms
   D. All.
6. The following are **not** ways that you can protect yourself and others against pathogens.
   A. Wash your hands often.
   B. Get vaccinated and ensure vaccinations are up to date.
   C. Prepare, cook, and store meat and other foods properly.
   D. Share drinking glasses or utensils.

1 ***Note:*** **Satisfactory rating - 10 points** **Unsatisfactory – 10 below 6points**

Answer Sheet

Score = ___________
Rating: ____________

Name: ___________________________

Date: ________________

1._____, 2. _______, 3. _______, 4. ______5, ______6. . ______

Operation Sheet -1	Identifying waterborne microorganisms found in water source

Steps to Identifying waterborne microorganisms found in water source

1. Identifying water source
2. Select materials and tools
3. Inspecting the work site
4. Record the data
5. Organizing the data
6. Report the data
7. Evaluate the results

Operation Sheet -2	Identifying characteristics of microorganisms

Steps to Identifying characteristics of microorganisms in water follow.

1. Identifying water Source
2. Select tools and materials.
3. Inspecting the work site
4. Observe microorganism
5. .Record the data
6. .Organizing the data
7. .Report the data
8. Evaluate the conditions water source

Operation Sheet -3	Identify water quality

Steps to Identify Identify water quality.

1. Identifying water asset and water source location
2. Select tools and materials
3. .Inspecting the work site
4. .Record the data
5. .Organizing the data
6. .Report the data
7. Evaluate the conditions water source

Operation Sheet -4	Identifying water treatment processes for microorganisms problems

Steps to Identify Identifying water treatment processes for microorganisms problems

3. Identifying water Source
4. Select tools and materials.
5. Inspecting the work site
6. .Record the data
7. .Organizing the data
8. .Report the data
9. Evaluate the conditions of water sources

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to Select Water Treatment Requirements for Waterborne within 8 hr.

- **Task1.** Identifying waterborne microorganisms found in water source
- Task2 Identifying general characteristics of microorganisms
- Task 3 Identify water quality and Treatment problems of microorganisms
- Task 4 Identifying water treatment processes for microorganisms problems
- Task 5 Identifying characteristics and diseases of pathogenic microorganisms

Instruction Sheet	Learning guide 44 Identify processes to remove microorganisms

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Assessing effectiveness of filtration processes for removing pathogenic microorganisms
- Assessing effectiveness of disinfection processes for inactivating pathogenic Microorganisms
- Identifying by product formation from disinfection processes
- Assessing metabolic. nuisance and toxicity problem of pre or post treatment Processes

This guide will also assist you to attain the learning outcome stated in the cover page.

Specifically, upon completion of this Learning Guide, you will be able to:

- Assessing effectiveness of filtration processes for removing pathogenic microorganisms
- Assessing effectiveness of disinfection processes for inactivating pathogenic Microorganisms
- Identifying by product formation from disinfection processes
- Assessing metabolic. nuisance and toxicity problem of pre or post treatment Processes.

Learning Instructions:

1 Read the specific objectives of this Learning Guide.

2 Follow the instructions described below

3 Read the information written in the "Information Sheets 1- 4". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.

4 Accomplish the "Self-checks 1, 2, 3 & 4" in each information sheets on pages 45, 50, 56 & 63,

5 Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6 If you earned a satisfactory evaluation proceed to "Operation sheets 1, 2, 3, & 4 on pages 64 and do the LAP Test on page 65". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

7 After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;

8 Then proceed to the next LG.

Information Sheet-1	Assessing effectiveness of filtration processes for removing pathogenic microorganisms

2.3. Introduction to filtration processes.

Water filtration is the process of removing or reducing the concentration of particulate matter, including suspended particles, parasites, bacteria, algae, viruses, and fungi, as well as other undesirable chemical and biological contaminants from contaminated water to produce safe and clean water for a specific purpose.

Filtration is a process that removes particles from suspension in water. Removal takes place by a number of mechanisms that include straining, flocculation, sedimentation and surface capture. Filters can be categorized by the main method of capture, i.e. exclusion of particles at the surface of the filter media i.e. straining, or deposition within the media i.e. in-depth filtration.

Strainers generally consist of a simple thin physical barrier made from metal or plastic. In water treatment they tend to be used at the inlet to the treatment system to exclude large objects (e.g. leaves, fish, and coarse detritus). These may be manually or mechanically scraped bar screens. The spacing between the bars ranges from 1 to 10 cm. Intake screens can have much smaller spacing created by closely spaced plates or even fine metal fabric. The latter are usually intended to remove fine silt and especially algae and are referred to as micro strainers.

Filters, as commonly understood in water treatment generally consist of a medium within which it is intended most of the particles in the water will be captured. Such filters might be manufactured as disposable cartridge filters, which can be suitable for domestic (i.e. point-of-use treatment) and small-scale industrial applications. Larger forms of cartridge filters exist which can be cleaned.

One version is pre coat filtration in which a porous support surface is given a sacrificial coating of diatomaceous earth, or other suitable material, each time the filter has been cleaned. Additionally, a small amount of the diatomaceous earth is applied continuously during filtration. However, in most cases, filters used in municipal water treatment contain sand or another appropriate granular material (e.g. anthracite, crushed glass or other ceramic material, or another relatively inert mineral) as the filter medium. Filtration using such filters is often referred to as in-depth granular media filtration.

Granular media filters are used in either of two distinct ways which are commonly called slow-sand filtration and rapid gravity or pressure filtration. When the filters are used as the final means of particle removal from the water, then the filters may need to be preceded by another stage of solid-liquid separation (clarification) such as sedimentation (Sedimentation Processes), dissolved-air flotation (Flotation Processes) or possibly a preliminary stage of filtration.

Other processes take place in vessels similar to those used for granular media filtration, and in some respects the processes do have similarities with filtration but filtration is not their sole or primary purpose. Therefore, such processes are not considered further in this article. Examples include vessels filled with granular activated carbon for removal of dissolved organic substances, and vessels filled with ion exchange resin for removal of inorganic and organic ions. There are applications of filters that whilst filtration (removal of particles) does take place a secondary process is intended to also occur, e.g. iron and manganese removal, and arsenic removal.

- ✓ **Strainers**

There is a vast variety of strainers with respect to how the straining is carried out, with and by what (Purchas, 1971). The straining part might be made of metal or other inert material e.g. plastic, cotton or a ceramic. If metal, it could be simply a perforated sheet, a grid of rods, a stack of discs or woven wire. If plastic, it could be a grid, woven or simply a fused felt. In cartridge filters the usually disposable cartridge might simply consist of a porous and non-compressible material or be cord wound on a cylindrical support. Cartridge filters find application generally in small scale applications such as for domestic point-of-use water treatment.

Only a few types of strainers are likely to find application in municipal water treatment. Some require manual cleaning others are cleaned mechanically and even automatically when the pressure drop across them reaches a specific value. A water treatment works might have a simple bar strainer at its inlet to keep out logs, large fish and swimming animals. Next there might be a fine strainer with its aperture small enough to exclude all but the smallest of fish, leaves, clumps of algae etc . Generally, this strainer would have to be automatically cleaned. Where algae might be a distinct problem then the bar strainer might have closely spaced bars and be automatically cleaned followed by a micro strainer.

One particular type of mechanical strainer has found limited application in smaller municipal water treatment works. The straining medium is a bundle of fibres. In filtration mode the bundle is twisted tight. In the wash mode the bundle is untwisted and the trapped detritus removed by reversing the flow of water.

- ✓ **Pre coat Filters**

In pre coat filtration a thin layer of an inert medium is laid down on a support structure to provide a porous straining surface. The pre coat layer might be created with loose fibres or powders (Purchas, 1971). A small quantity of the pre coat or other similar material might be added continuously during filtration such that some in-depth filtration also then takes place. When resistance to flow becomes too great then the accumulated detritus and inert medium are discharged and the cycle repeated. In most instances the pre coat material is used just once and is not recovered and recycled.

Pre coat filtration is unlikely to be used in conjunction with coagulation and therefore its application in municipal water treatment is very limited.

- ✓ **Slow Sand Filters**

In slow sand filtration the rate of filtration is intentionally slow with use of sand that is smaller than sand used in rapid sand filters, so that particles are not driven far into the bed of sand held within the filter shell.

The principal mechanisms taking place in slow sand filters is accumulation of a layer of debris on the surface of the filter (straining) and capture within about the top 20 cm of the sand. This debris is allowed to develop biological activity which contributes to the treatment of the water passing through it.

This biologically active layer is often called the 'schmutzdecke'. Because the filtration rate is relatively slow the resistance to flow through slow sand filters develops slowly and may take up to 3 months before it becomes unacceptable. Because filtration rate is slow a large area for filtration is needed. Consequently, the large filters are cleaned by removing the schmutzdecke with about 5 cm of sand usually by mechanical means. Eventually the depth of sand remaining becomes too shallow and the remaining sand is removed, cleaned and replaced with additional clean sand back to the original starting depth.

Slow sand filtration was the main method of filtration of potable water before rapid sand filtration was developed. Although it has a large footprint, many slow sand filters are still used. Developments to make them more cost effective have included:

- ✓ Sand removal, washing and replacement have been mechanized as much as possible.
- ✓ The need for sand removal has been made as predictable as possible so that the equipment and labor is efficiently utilized.
- ✓ Filtration rates have been increased as much as possible to improve the economics and contribute to predictability of need for sand removal.
- ✓ Pre-treatment, including raw water storage and management, is applied to reduce the impact of solids in suspension and contribute to predictability.
- ✓ Granular activated carbon has been used in some filters to replace the lower part of the sand to help with removal of pesticides, taste and odour and other trace organic substances that the biological mechanism does not deal with effectively.

There are two important requirements for slow sand filters to function properly. Firstly, the water entering the filters must not contain any disinfectant or other chemical that might interrupt the biological activity of the schmutzdecke. Secondly, if pre-treatment is carried out with coagulation then most of the resulting floc particles must be removed as part of the pre-treatment, otherwise the floc will accelerate the rate at which resistance to flow through the filter develops.

- ✓ **Rapid Gravity and Pressure Filters**

In-depth granular media filtration can be carried out under gravity (rapid gravity filtration) or under pressure (pressure filtration). The basic mechanisms of particle removal are fundamentally the same in both gravity and pressure modes. The principal differences between the two modes are likely to be hydraulic, notably distribution of flow between filters and control of flow through individual filters.

The filter media is usually sand, but other relatively inert material can be used, but the choice depends on costs and what other objectives there might be. In some cases, part of the sand might be replaced with anthracite. The lower density of the anthracite allows a larger grain size to be used such that after backwash the larger anthracite sits on top of the smaller sand. In this way filtration takes place through first a larger and then a smaller media to help make better use of filter bed depth.

The principal mechanism of in-depth filtration is surface capture. The area of media available for surface capture depends on both media depth and size. Depth and size also govern the space available for storage of captured detritus. Grain shape of the filter media also affects capture and storage, in that angular particles are preferable to rounded particles. The choice of size has to take account of how quickly the medium might become blocked by captured detritus and the ease with which it can be backwashed.

Regardless of the choice of media material, size tends to be limited to the range 0.5 to 2.0 mm. The greatest application of in-depth filtration in municipal water treatment is after coagulation, perhaps also with prior clarification. The choice of coagulation chemistry, its application and any clarification, govern the nature and quantity of the particles to be removed by the filtration, which in turn affect the choice of filter media, depth and filtration rate.

In potable water treatment, in-depth filtration is often the last, and sometimes the only, physical barrier to particles. Therefore the performance reliability of the filters is important in ensuring the quality of the water on completion of treatment complies with the standards. The standards defined by the relevant regulations have become substantially more rigorous as they have developed over the past 50 years. Reliability of exclusion of Cryptosporidium oocysts has been of particular concern.

The bed of granular filter media is cleaned by applying backwash. This generally involves: draining down the water until its upper surface is at about the same level as the top of the media, loosening the bed with air (air scour), applying water upwash at a rate great enough to just fluidize the functional part of the bed of filter media, allow a short interval for the media to settle, and starting to refill the filter with water from above the bed whilst opening the outlet so that filtration starts slowly. A more rigorous backwash can be achieved if the water up wash is started at a reduced rate whilst the air scour is occurring (combined air-water wash). Older filter installations sometimes have other features like mechanical rakes or surface flush that operate during up wash. The viscosity of water depends on water temperature. Therefore, it is important that the rate of up wash takes account of water temperature to ensure the filter media is fluidized.

It is usual to have at least four filters, so that the filtration can continue whilst one filter is backwashed. Large treatment works have many more than four in a group, and possibly two or more independent groups of filters.

- ✓ **Problems with operating in-depth filters include**:

  - ✓ Loss of media during backwash,
  - ✓ Ineffective backwashing resulting in mud-binding of the media and its associated symptoms.
  - ✓ Short filter runs due to either rapid rate of head loss or early breakthrough of particles.

These are usually indicators of the likes of incorrect up wash rate, problems with the underdrain system, excessive dosing of polyelectrolyte, presence of filter-blocking algae, inappropriate choice of either or both filter media size and depth, or simply either or both inadequate prior coagulation and clarification. Trouble-shooting should also check to what extent distribution of flow between filters in a bank or group is equitable or not.

- ✓ **Novel Forms of Granular Media Filters**

There are a number of relatively novel forms of granular media filters. Each is a 'horse for a course' having its specific set of advantages and disadvantages and therefore relative appropriateness for certan applications.

- ✓ **Up flow filters**

In normal in-depth granular media filtration the flow of water is down through the filter bed, except during backwashing. Up flow of water during filtration is possible; it offers an advantage but also poses problems. With backwashing of the filter media, normally the media is encouraged to stratify with the largest and densest material towards the bottom of the filter bed and the smallest and lightest towards the top. This means that in downward filtration, the filtration is progressively through increasingly larger media, unless the media is tightly graded before installation.

This contradicts the ideal bed geometry of filtration through progressively smaller media. It follows that that one way of avoiding this situation is to filter upwards. Upward filtration allows the capacity of the media to collect and store solids to be exploited better. However, as the filter bed accumulates deposit and the resistance to flow through it increases the bed progressively becomes more likely to be hydraulically disrupted. Two approaches have been used to restrict this hydraulic disruption.

The Immedium filter uses a simple metal grid about 15 cm below the top of the bed to help keep the bed compacted. The Bi flow filter applies down flow filtration to the top of the bed to keep the lower part with up flow filtration compacted.

A reservation for the use of up flow filters as the final stage of solids removal in potable water treatment is that backwash flow is in the same direction of filtration. Another reservation is that filter breakthrough can happen suddenly. Consequently, upflow filters are more likely to be found in applications where protection of treated water quality does not have to be as rigorous as required for potable water treatment, although they might be appropriate to use as a clarification stage prior to normal in-depth filtration.

- ✓ **Immedium filters**

The Immedium filter was developed in the Netherlands in the 1960's. The key feature is the use of a simple metal grid across the filter bed about 15 cm below the top of the sand. The grid delays the onset of breakthrough of particles in the water. The grid helps to maintain compaction of the sand and delays the start of localised penetration of flow as the water finds paths of least resistance through the sand. A point is reached when the flow through such a low resistance path is too great for particles to be removed and is great enough to fluidise the sand in the upper part of the flow path. This can be observed at the upper surface of the bed by the appearance of 'blow holes'.

- ✓ **Bi flow filters**

The Bi flow filter was developed as an alternative to the Immedium filter. As the name implies, flow for filtration is in two directions. The larger proportion of flow is upwards from the base of the filter bed, whilst the smaller proportion is downwards from the top of the filter bed. The two flows meet a short way down the bed where there is an outlet grid across the bed. When the filter needs washing both flows are stopped and air scour applied for a few minutes before water up wash is carried out to wash out the detritus. Combined air and water up wash can be carried out only if the filter has been designed for this.

- ✓ **Buoyant media filters**

Whilst in Immedium and Bi flow filters the filter sand is kept compacted, in buoyant media filters the media is chosen to be buoyant and is retained in the filter by a straining mesh above the media. The media is selected to have a low density and accordingly is usually a plastic. During the filtration mode the media is in a compacted state under the retaining mesh. When the media needs to be washed to clean out the captured detritus, the upflow rate is reduced to release the compaction and air is bubbled up through the bed. Buoyant media filters have been used in water treatment as a clarification stage prior to normal filtration

- ✓ **Moving bed filters**

All the granular media filters described above have flow through for filtration stopped whilst they are backwashed. In a moving bed filter, the filter media is constantly moving so that filtration is not interrupted for the sand to be backwashed. The sand in the filtration zone slowly moves downward due to its own weight against the up flow of the water being filtered. In the conical base of the filter the sand is hydraulically carried into a vertical tube up through the centre of the filter bed. As the sand is carried up through the tube the filtered deposits are released. At the top of the tube above the filter bed the sand settles out from the wash water and feeds back to the top of the filter bed whilst the dirty wash water is kept separate from the filtered water emerging from the top of the filter. In order that the proportion of water lost in the wash stream is kept small, moving bed units should be operated close to design capacity.

✓ **Cell filters**

There is a maximum size to which a normal filter can be built if the whole of the filter bed is to be backwashed at the same time. If the filter bed can be backwashed in sections then the filter shell can be larger. A bed can be backwashed in sections by having the filter bed divided by walls from the filter floor to just above the bed so that a hood can be placed over the section to be backwashed. The hood is mounted on a gantry that runs on rails along the top of the main side walls of the filter. This approach results in reduced civil engineering costs but greater mechanical engineering costs, compared to a larger number of filters of equivalent total filtration area. The operational reliability of a cell filter depends much on the functioning of the gantry and hood system and how effectively the hood seals with the walls of a cell.

✓ **Automatic backwash filters**

As deposits accumulate in a filter bed the resistance to flow through the bed increases. Flow can be kept constant by having an outlet valve that is progressively opened and provide less resistance to flow through it to compensate for the increased resistance to flow through the bed. In this way the level (head) of water above the media remains relatively constant. Alternatively, the flow to the filter is kept constant and the flow through the filter remains relatively constant with the level of water above the bed increasing. If the filter is contained in a deep shell then the increasing level of water can be used to prime a siphon. When the level reaches a predetermined level the siphon is activated and is used to draw water up through the filter to cause backwash. A risk is that the upwash rate of water may be inadequate for effective backwashing. However, the design lends itself to package plant and situations where quality and quantity of particles to be removed remains relatively constant. The design is unlikely to be suitable for potable water treatment.

✓ **Horizontal and radial filters**

✓ **Horizontal filters**

Instead of the flow of water being up or down through a filter bed, it can be horizontally across through the bed. If the filter bed is contained in a rectangular tank then the filtration rate remains constant along the length (inlet to outlet) of the filter. The filter can be backwashed hydraulically as required. It would be necessary for the main filter material to be as uniform in size as possible so that there is not a distinct bias through the depth due to stratification of the media by size by the backwashing, or the backwash is arranged to keep the media mixed. A horizontal filter could be split into two or more sections each with a different size media, with a vertical mesh between each to keep the different size media separated. The backwash of each section would need to take account of this.

Horizontal filters have been used filled with gravel (pebbles) of selected sizes in third world situations for use as clarifiers. Because the size of the gravel precludes normal backwashing, they filters are routinely cleaned by draining and hosing and occasionally by removing the gravel for washing.

- ✓ **Radial filters**

A radial filter is a horizontal filter but with increasing width of filter bed in the direction of flow. The ultimate shape of the filter bed is annular in cross-section with flow from the centre to the periphery. The rate of filtration decreases as the water progresses through the filter media so allowing progressively more efficient removal of particles.

- ✓ **Membrane Filters**

Historically cloth has been used to filter water. In microstraining the water is filtered through fabric made from finely woven wire. In both these cases the cloth or fabric is a kind of membrane, albeit a coarse one. Modern technology allows manufacture of membranes from synthetic materials, to be less than about 1mm thick and be semi-permeable. Being semi-permeable means that the membrane is selective in what submicron-size particles can and cannot pass through it that is in the feed stream. During operation, permeable components in the water pass through the membrane with the water whilst impermeable submicron-size components are retained on the feed side. Consequently, the product stream is relatively free of the impermeable components and the waste stream is rich in impermeable components. Flow of water through such a semi-permeable membrane is achieved by pressure, usually produced by pumping.

There are four categories of membranes loosely defined by the types of materials rejected, operating pressure and nominal pore size. The categorisation of pore size is approximate since, for example a high-end UF membrane can have similar permeability to a low-end NF membrane:

- ✓ Microfiltration (MF) - approx 0.1 µm pores: impermeable to particles, algae, animalcules and bacteria
- ✓ Ultrafiltration (UF) – approx 0.01 µm pores: impermeable to small colloids and viruses
- ✓ Nanofiltration (NF) – approx 0.001 µm pores: impermeable to dissolved organic matter (DOM) and divalent ions
- ✓ Reverse osmosis (RO) – effectively non-porous: impermeable to monovalent ions

The predominant mechanism in MF and UF is straining, or simple size exclusion. In NF and RO separation of dissolved species involves mass transfer, a process of diffusion that depends on concentration, pressure and rate of flow through the membrane (flux). Consequently, membrane filtration usually refers to MF and UF but not NF and RO, whilst NF is usually considered to be a form of RO.

The thickness of membranes means that they have to be formatted in a way that provides structural strength, so they will not collapse because of the pressure difference across them, provide a large area for filtration but are compact and can be cleaned effectively. They are generally structured as thin tubes (hollow fibres) or as a coiled sheet. A coil is a sandwich of the semi-permeable membrane, a separating mesh, a thin sheet of impermeable material and a second layer of thin mesh. The layers of mesh provide the channels for flow to the inlet and from the outlet side of the membrane.

It is usual to include a preliminary stage of treatment before membrane filtration to protect the membrane from being fouled too rapidly by excluded material, although there are also ways to operate membrane filters to slow the rate of fouling of the membrane before having to apply a cleaning process. The routine, and frequent, cleaning process is flushing to remove the accumulated detritus on the feed side. However, over time there is a slow loss in membrane performance that can only be recovered by chemical cleaning.

Membrane filtration (MF, UF and low end NF) have become relatively common in potable water treatment, such as for removal of colour from otherwise relatively good quality water so avoiding complexities associated with coagulation, and for reliable exclusion of Cryptosporidium.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each)

1. Problems with operating in-depth filters include:

    A. Loss of media during backwash,

    B. Ineffective backwashing resulting in mud-binding of the media and its associated symptoms.

    C. Short filter runs due to either rapid rate of head loss or early breakthrough of particles   D. all.

2. In normal in-depth granular media filtration the flow of water is down through the filter bed, except during backwashing.

    A. Up flow filters,

    B. Reverse osmosis

    C. Horizontal filters

    D. All.

3. Instead of the flow of water being up or down through a filter bed, it can be horizontally across through the bed

    A. Up flow filters,

    B. Reverse osmosis

    C. Horizontal filters

    D. All.

4. There are four categories of membranes loosely defined by the types of materials rejected, operating pressure and nominal pore size. The categorization of pore size is approximate since, for example a high-end UF membrane can have similar permeability to a low-end NF membrane:

    A. Microfiltration (MF) - approx 0.1 µm pores: impermeable to particles, algae, animalcules and bacteria

    B. Ultrafiltration (UF) – approx 0.01 µm pores: impermeable to small colloids and viruses

    C. Reverse osmosis (RO) – effectively non-porous: impermeable to monovalent ion

    D. . all

Note: **Satisfactory rating - 6 points and above** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 1

Score = ___________
Rating: ____________

Name: _________________________

Date: _______________

1._____, 2. _______, 3. _______, 4. ______

2.1. Introduction to disinfection processes

- **Destroying Pathogens and Requirements of a Disinfectant**

Disinfection of the outflow water from wetland systems might be required for particular applications such as recycling of treated water for irrigation purposes. Disinfection is carried out to destroy the microbiological agents that cause disease. It differs from sterilization, which implies the destruction of all microorganisms. Water supplies are usually disinfected. The widespread adoption of disinfection is a major factor in reducing waterborne diseases, and this has been interpreted as the major single factor in increasing average human life expectancy.

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Chlorination, usually performed as the final treatment process, is the most common means of disinfecting predominantly drinking water. Other processes, natural and artificial, aid in the destruction or removal of pathogens.

Most pathogens are accustomed to the temperatures and conditions in the bodies of humans and animals; they do not survive outside such environments. Nonetheless, significant numbers can survive in potable water. Some pathogens, particularly certain viruses and those organisms that form cysts, can survive for long periods even under the most adverse conditions. Because such organisms also tend to be resistant to chlorine doses normally used in water treatment, chlorination alone cannot always ensure safe drinking water.

Storing water for extended periods of time in open tanks or reservoirs prior to treatment can accomplish some destruction of pathogens through sedimentation and natural death of the organisms. Significant pathogen removal occurs in the water and wastewater treatment processes.

A disinfectant must be able to destroy particular pathogens at the concentrations likely to occur, and it should be effective in the normal range of environmental conditions. Disinfectants, which require extremes of temperature or pH or which are effective only for low-turbidity waters, are unlikely to be suitable for large-scale use.

While the disinfectant should destroy pathogens, it must not be toxic to humans or other higher animals (e.g., fish) in a receiving watercourse. Ideally, some residual disinfecting capacity should be provided for a water supply network to provide protection against reinfection while the water is in the distribution system. The residual, which passes to the consumer, should be neither unpalatable nor obnoxious.

A disinfectant should be safe and easy to handle, both during storage and addition to the process water. The other major consideration is cost, which is particularly important for municipal plants where large volumes are commonly disinfected continuously

The use of water disinfection as a public health measure reduces the spread of diseases. Various disinfection technologies can be used to meet the pathogen inactivation demand in water. This work is an overview of the main disinfection technologies of wastewater and drinking water that reports for the conventional processes the action mechanism, the possible formation of by-products, the operative conditions, the advantages and disadvantages. For advanced and natural processes the action mechanisms are reported. Advanced technologies are interesting but are still in the research state, while conventional technologies are the most used. There is a tendency, especially in Italy, to use chlorine-based disinfectant, despite in some forms could lead to production of disinfection by-products.

To ensure microbiological quality disinfection treatment is of primary importance. Using disinfectants, pathogenic bacteria from the water can be killed and water made safe for the user.. The World Health Organization (WHO) provide the guidelines for drinking water quality in the protection of public health

The guidelines provide the recommendations for managing the risk from hazards that may compromise the safety of drinking water and provide a scientific point of departure for national authorities to develop drinking water regulations and standards appropriate for the national situation. The guidelines are intended to support the development and implementation of risk management strategies that will ensure the safety of drinking water supplies through the control of hazardous constituents of water. Securing the microbial safety of drinking-water supplies is based on the use of multiple barriers, from catchment to consumer, to prevent the contamination of drinking water or to reduce contamination to levels not injurious to health. Safety is increased if multiple barriers are in place, including protection of water resources, proper selection and operation of a series of treatment steps and management of distribution systems (piped or otherwise) to maintain and protect treated water quality. The preferred strategy is a management approach that places the primary emphasis on preventing or reducing the entry of pathogens into water sources and reducing reliance on treatment processes for removal of pathogens

The Guidelines for Drinking Water Quality describe four distinct types of health-based targets, applicable to all types of hazards and water supplies:

- ✓ Health outcome targets (e.g., tolerable burdens of disease);
- ✓ Water quality targets (e.g., guideline values for chemical hazards);
- ✓ Performance targets (e.g., log reductions of specific pathogens);
- ✓ specified technology targets (e.g., application of defined treatment processes)

The quality assessment microbiological of water is based on the definition and the search for indicator organisms. In a quantitative microbial risk assessment it is not possible to consider all human enteric pathogens; therefore, reference pathogens are chosen that are of particular relevance to the exposure pathways and context of the individual risk assessment. Reference pathogens are intended to provide a conservative model for the risk assessment: if the reference pathogen is controlled, it is assumed that other important pathogens within each class would also be controlled. When considering human enteric pathogens, at least one bacterium, one virus and one protozoan are typically recommended in order to cover the range of behaviors in the main enteric pathogen groups. Inclusion of a representative helminth (e.g., Ascaris) is recommended for wastewater reuse and sanitation-based scenarios.

The key objective is to achieve a quality of reclaimed water that is appropriate for the intended use and is protective of human health and the environment. Regarding the microbiological quality of drinking water, the standards currently in force in Italy take as indicator the Enterococchi and Escherichia coli. On the other hand, for wastewater the standards currently in force in Italy take as the single indicator of faecal pollution the Escherichia coli.

The factors to be considered in choosing the disinfection treatment are:

- ✓ The water characteristics (type and concentration of microorganisms);
- ✓ the effluent final quality;
- ✓ the disinfectant agent toxicity;
- ✓ the disinfection by-products formation;
- ✓ plants characteristics (WWTPs and DWTPs);

- ✓ **Costs.**

Moreover, the disinfection efficiency is affected by several interferences, such as ferrous and manganese ions, nitrites, sulphides and organic substances, that reduce the concentration of oxidizing disinfectants with the consequent reduction of microorganisms inactivation

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each)

1. The factors to be considered in choosing the disinfection treatment are:

   A. The water characteristics (type and concentration of microorganisms);
   B. the disinfectant agent toxicity;
   C. The disinfection by-products formation; D. All.

2. The Guidelines for Drinking Water Quality describe four distinct types of health-based targets, applicable to all types of hazards and water supplies:

   A. Health outcome targets (e.g., tolerable burdens of disease);
   B. Water quality targets (e.g., guideline values for chemical hazards);
   C. Performance targets (e.g., log reductions of specific pathogens); D. All.

3. The key objective is to achieve a quality of reclaimed water that is appropriate for the intended use and is protective of human health and the environment.

   A. True B. false.

4. Chlorination, usually performed as the final treatment process, is the most common means of disinfecting predominantly drinking water. Other processes, natural and artificial, aid in the destruction or removal of pathogens. True B. false.
5. Disinfection is carried out to destroy the microbiological agents that cause disease.

   A. True B. false.

Note: **Satisfactory rating - 4 points and above Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 2

Score = ____________

Rating: _____________

Name: ___________________________

Date: ________________

1._____, 2. _______, 3. _______, 4 _______, 5. _______,

Information Sheet-3	Identifying by product formation from disinfection processes

3.1 Introduction to by- product formation

By-Products Formation Disinfection processes can result in the formation of both organic and inorganic disinfection by-products (DBPs) . Chlorine, in presence of natural organic substances, produces trihalomethane and acetoacetic, known to be carcinogenic to humans. The trihalomethanes (THMs) are generally the most prevalent. These are a volatile group of compounds, which comprises chloroform, bromodi chloromethane (BDCM), chloro dibromomethane (CDBM), and bromoform. Chlorine reacts with natural organic compounds (such as humic and fulvic acids) to form a wide range of unwanted halogenated organic compounds including THMs, halo acetic acids (HAAs), chlorophenols, chloral hydrate, and haloacetonitriles (HANs). Chloroform is usually the most prevalent by-product formed, although brominated THMs can occur at high concentrations when waters with high bromide concentrations are chlorinated. Most other DBPs occur at trace concentrations

The disinfection of water containing dimethylamine with chlorine leads to the formation of NDMA (N-nitrosodimethylamine). The concentration of NDMA is closely related to the ratio of chlorine, ammonia ions and dimethylamine.

During disinfection with chlorine dioxide, chlorite (ClO_2^-) and chlorate (ClO_3^-) are the major reaction by-products, potentially toxic. It is believed that the degradation of the residual chlorine dioxide and other final reaction products is faster than that observed in the case of chlorine and therefore these compounds should not represent a hazard to the aquatic environment.

During the disinfection with ozone, the formation of organic (e.g., aldehydes, carboxylic acids, and ketones) and inorganic (e.g., bromate) disinfection by-products has been well documented. Ozone does not cause the formation of chlorinated by-products such as trihalomethane, but recent studies indicate that ozone induce the formation of NDMA. The PAA dosage to the water causes the formation of aldehydes at very low concentrations.

Table 2.1 conventional disinfection technology against different microbial group

Conventional Technologies	Advantages	Disadvantages	Application
Chlorine	Easy to handle and economical; Residual concentration; Technologies consolidated	High contact time; By-product formation; Residual toxicity of the effluent; Very corrosive	Drinking water; Wastewater
Chlorine dioxide	More effective than chlorine over short contact; Long residual	Residual toxicity of the effluent; By-product formation; Generation onsite; Medium-high management costs; Increase the concentration of solids in the effluent	Drinking water; Wastewater
Ozone	Short contact time	No residues of disinfectant; By-product formation; Generation onsite; High energy demand; High management costs	Wastewater
Peracetic acid	Simple solution; Residual concentration	Increase BOD and COD concentration in the effluent; By-product formation	Wastewater
UV radiation	No by-products formation; Short contact time; Inactivation of virus	No residues; High energy demand; High cost; Unsuitable for water with high levels of suspended solids, turbidity, color or soluble organic matter	Wastewater

Water disinfection is a treatment aimed at reducing the presence of pathogenic microorganisms in the water, with variable removal rates, as shown in Table 2.1. In particular, the CT (CT value is the product of the concentration of disinfectant agent in the water and the time of contact) values for 99% (2-log) and 99.99% (4-log) inactivation of bacteria and viruses for various disinfectant agents are reported.

The concept of disinfectant concentration and contact time is important to the understanding of disinfection kinetics and the practical application of CT concept (which is defined as the product of the residual disinfectant concentration C, expressed in mg L^{-1}, and the contact time T, expressed in minutes, that residual disinfectant is in contact with water) is important. CT value represents an operative parameter and it is an indicator of the effectiveness of the disinfection process.

Table 2.2. Disinfectant dosage for bacteria and viruses inactivation

Disinfectant Agent	Measurement Unit	Bacteria Inactivation		Viruses Inactivation	
		2-log	4-log	2-log	4-log
Chlorine	(mg min L^{-1})	0.1–0.2	10–12	2.5–3.5	6–7
Chlorine dioxide	(mg min L^{-1})	8–10	50–70	2–4	12–20
Ozone	(mg min L^{-1})	3–4	-	0.3–0.5	0.6–1.0
UV radiation	(mJ cm^{-2})	30–60	80–100	20–30	70–90

Disinfection of drinking water using oxidative methods will generate unwanted chemical by-products. Recent chemical monitoring studies indicate that these disinfection by-products (DBPs) likely represent more than 600 different chemicals that vary in concentration from less than a nanogram per liter up to microgram per liter levels. The exact composition of DBPs in disinfected drinking water is known to vary substantially depending on the mineral content of the source water, the type of disinfection method used, and daily and seasonal hydrologic fluctuations. Thus, it is important to recognize that drinking water DBPs are a complex mixture that can exhibit geographical variations and change with the seasons. Toxicological studies have tended to focus on those DBPs that are typically found at microgram per liter concentrations, and the understanding of DBP toxico kinetic properties is limited to a relatively few number and classes of chemicals.

- **Disinfection By-Products**

DBPs that form when disinfectants are added to water are potentially toxic and/or are carcinogenic substances. Depending on the disinfectant used and the precursor materials present in the water, several classes of DBPs may form, including trihalomethanes (THMs), haloacetic acids (HAAs), chlorate, chlorite, bromate, and haloacetonitriles (HANs). The most common precursors of DBPs is natural organic matter (NOM) such as organic debris and leaves that find their way into surface waters. While serving the purpose of killing pathogens in raw water, the disinfectant may also react with precursor material, mainly dissolved organic matter, to form DBPs. Several factors are responsible for the concentration of DBPs formed. Most influential among these factors are total organic carbon (TOC) concentration, chlorine dose and contact time, pH, and temperature.

Disinfection is a process that deliberately reduces the number of pathogenic microorganisms in water to achieve the principal objective of drinking water treatment: protection of public health. Disinfection of water is often needed to assure its drinkability. The use of chemical disinfectants was made in as large quantities as required to achieve the desired quality. Currently, there are several options for the disinfection of drinking water, each with its own merits as a disinfectant and the presence of by-products that must be minimized. The disinfection process is expected to satisfy the following three requirements: inactivation of the pathogenic and other harmful microorganisms in water (primary disinfection), disinfectant residual maintenance in the distribution system (secondary disinfection), and keeping the amount of by-products to a minimum.

Different disinfectants offer different performances toward the achievement of these three requirements. Regular monitoring is the responsibility of the public water system. A certified drinking water laboratory must analyze collected samples. It is required that disinfectant residual be measured monthly at the end of each treatment process that uses chlorine.

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each)

1. By-Products Formation Disinfection processes can result in the formation of both organic and inorganic disinfection by-products (DBPs)
   A. True. False.
2. During disinfection with chlorine dioxide, chlorite (ClO2 −) and chlorate (ClO3 −) are **not** the major reaction by-products, potentially toxic.
   A. True. False.
3. Water disinfection is **not** a treatment aimed at reducing the presence of pathogenic microorganisms in the water, with variable removal rates
   A. True. B. false.
4. The concept of disinfectant concentration and contact time is important to the understanding of disinfection kinetics and the practical application of CT concept
   A. True. B. false.

Note: **Satisfactory rating - 4 points and above** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 3

Score = ___________

Rating: ____________

Name: ___________________________

Date: ________________

1.______, 2. ________, 3. ________, 4. ________,

4.1. Introduction to pre or post water treatment Processes

Pre-treatment is the removal of specific pollutants from produced water before mixing it with the main produced water stream, wherein the recovery of some contaminants may occur.

A pre-treatment is necessary in order to protect raw water lifting systems and pipelines against blockages as well as other treatment equipment against abrasion and, more generally, to remove anything that might interfere with subsequent treatment.

The following constitute pre-treatment operations (a water treatment plant can comprise one or more of these operations, depending on its importance and raw water quality:

- ✓ bar screening;
- ✓ straining;
- ✓ comminution;
- ✓ grit removal ;
- ✓ grease removal, frequently combined with grit removal ;
- ✓ oil removal;
- ✓ by-product treatment: grit and grease;
- ✓ Combined treatment of mains cleaning waste and of plant grit.

Similar operations can be carried out on:

- ✓ water taken from a river supply point;
- ✓ Industrial wastewater.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next

Instruction I: Choose the best answer for the following question (2pts each):

***Note:* Satisfactory rating - 8 points and above Unsatisfactory - below 8 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 4

Score = ___________

Rating: ____________

Name: ___________________________

Date: ________________

1.______, 2. ________, 3. ________, 4. _______5, _______

Operation Sheet -1	Assessing effectiveness of filtration processes for removing pathogenic microorganisms

Steps to Assessing effectiveness of filtration processes for removing pathogenic microorganisms

1. Identifying tools and equipment's
2. Inspecting water source
3. Recording the inspected data
4. Identify appropriate methods. Repairing
5. Check the functionality and effectiveness
6. Organizing and Report the data
7. Evaluate the results.

Operation Sheet -2	Assessing effectiveness of disinfection processes for inactivating pathogenic Microorganisms

Steps to Assessing effectiveness of disinfection processes for inactivating pathogenic Microorganisms

1. Identifying tools and equipment's
2. Inspecting water source.
3. Recording the inspected data
4. Identify appropriate methods Of instruction.
5. Check the functionality and effectiveness
6. Organizing and Report the data
7. Evaluate the results

Operation Sheet -3	Identifying by product formation from disinfection processes

Steps to Identifying by product formation from disinfection processes

1. Identifying tools and equipment's
2. Inspecting water source
3. Recording the inspected data
4. Identify appropriate methods Of operation procedures
5. Check the functionality and effectiveness
6. Organizing and Report the data
7. Evaluate the results

Operation Sheet -4	Assessing metabolic. nuisance and toxicity problem of pre or post treatment Processes

Steps assessing metabolic. nuisance and toxicity problem of pre or post treatment Processes

1. Identifying tools and equipment's
2. Inspecting water source
3. Recording the inspected data
4. Identify appropriate methods Of operation procedures
5. Check the functionality and effectiveness
6. Organizing and Report the data
7. Evaluate the results

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to Select Water Treatment Requirements for Waterborne within 8 hr.

Task1 Assessing effectiveness of filtration processes for removing pathogenic microorganisms

Task 2. Assessing effectiveness of disinfection processes for inactivating pathogenic Microorganisms

Task 3. Identifying by product formation from disinfection processes**.**

Task 4. Assessing metabolic. nuisance and toxicity problem of pre or post treatment Processes

Instruction Sheet	Learning guile 45 Determine appropriate water treatment processes.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying optimum treatment processes for microorganisms in water sources
- Maintaining water quality by appropriate sampling and testing.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Identifying optimum treatment processes for microorganisms in water sources
- Maintaining water quality by appropriate sampling and testing.

Learning Instructions:

1 Read the specific objectives of this Learning Guide.

2 Follow the instructions described below

3 Read the information written in the "Information Sheets 1- 4". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.

4 Accomplish the "Self-checks 1, 2, & 3" in each information sheets on pages 70,74 &79,

5 Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6 If you earned a satisfactory evaluation proceed to "Operation sheets 1, 2, & 3 on pages 8 and do the LAP Test on page 81". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

7 After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;

Information Sheet-1	Identifying optimum treatment processes for microorganisms in water sources

1.1. Introduction to optimum treatment processes

Water is vital for everyday life and serves as an essential element to our health, hygiene and the productivity of our community.

Water treatment is any process that improves the quality of water to make it appropriate for a specific end-use. The end use may be drinking, industrial water supply, irrigation, river flow maintenance, water recreation or many other uses, including being safely returned to the environment.

The water treatment process may vary slightly at different locations, depending on the technology of the plant and the water it needs to process, but the basic principles are largely the same.

- **Conventional surface water treatment**

Conventional surface water treatment plants are still being used throughout the United States. They typically consist of several steps in the treatment process. These include: (1) Collection; (2) Screening and Straining ; (3) Chemical Addition ; (4) Coagulation and Flocculation ; (5) Sedimentation and Clarification ; (6) Filtration ; (7) Disinfection ; (8) Storage ; (9) and finally Distribution.

Let's examine these steps in more detail. Collection – The source water for a municipal surface water treatment plant is typically a local river, lake, or reservoir. There must be a method to get this water to the water treatment plant. Quite often, a series of pumps and pipelines transport the water to the treatment plant. Sometimes, as is the case of San Angelo, water from a reservoir such as Twin Buttes can be transported to the water treatment plant via a river. Twin Buttes Reservoir is one of the water sources for San Angelo. The water is released into Lake Nasworthy where it is transported down the Concho River to the water treatment plant. At the water plant, large pumps are used to transfer the water up to the treatment facility. Treatment facilities are often engineered to utilize gravity water flow as much as possible to reduce pumping costs.

Many water treatment plants utilize water from more than one source. Blending groundwater with surface water is a method often used to improve the quality of the final product.

Screening and Straining – If you think about surface water sources, i.e., lakes, rivers, and reservoirs, you realize they contain varying amounts of suspended and dissolved materials. This material may include turbidity, color, taste, odor, microorganisms, fish, plants, trees, trash, etc. The material may be organic or inorganic, suspended or dissolved, inert or biologically active, and vary in size from colloidal to a tree trunk. Some of these larger items can impede equipment in the treatment process, such as a tree limb getting stuck in a water pump impeller. So the first process in conventional water treatment is to screen or strain out the larger items. This is often accomplished using a large metal screen, often called a barscreen, which is placed in front of the water source intake. Large items are trapped on the screen as the water passes through it. These screens must routinely be raked or cleaned off

Chemical Addition – Once the pre-screened source water is received into the treatment plant, chemicals are added to help make the suspended particles that are floating in the water clump together to form a heavier and larger gelatinous particle, often called floc. In this process, a chemical is added that reacts with the natural alkalinity in solution to form an insoluble precipitate. There are many different chemicals on the market that are used in this process. These chemicals are called coagulants. One of the most common that has been used for many years is aluminum sulfate, or alum. Some other very 2 popular coagulants are ferrous sulfate, ferric chloride, sodium aluminate, activated silica, and compounds called polymers that are manufactured chemicals made up of repeated small units of low molecular weight combined into molecules with very large molecular weights. These polymers are classified as cationic polymers (positively charged), anionic polymers (negatively charged), and nonionic polymers (neutrally charged). Regardless of which coagulant or combination of coagulants is used, they must be mixed very well with the water before they can form a heavier floc

Coagulation and Flocculation - A rapid mix unit is usually used where the coagulant is added to the water to provide a very quick and thorough mixing. The water mixing is then slowed to allow the water to come in contact with the forming floc and allow it to increase in size. The continued mixing must be gentle to allow the floc to grow and gain weight, but fast enough to keep it in suspension until you are ready for it to settle in the clarifiers. The process of adding a chemical to cause the suspended material to "clump" into larger particles is called flocculation or coagulation. The treatment unit where coagulation and flocculation is performed is called the "flocculator".

Sedimentation and Clarification – Once the flocculation process is complete, the water then passes over the weir in the flocculator and travels to the center of the clarifier, or sedimentation basin. Here, the water makes its way from the center of the clarifier to the saw tooth weir at the perimeter of the unit. As the water makes its way towards the weir, the large floc particles are allowed to settle out to the bottom of the clarifier. A rake continuously travels across the bottom of the clarifier and scrapes the settled floc to the center of the unit. Pumps are used to pull the settled "sludge" out of the clarifier and send it to a sedimentation / disposal pond.

The water that passes over the weir is collected and transferred to the filters. The reason clarification occurs before filtration is so the majority of suspended material can be removed prior to filtration, which avoids overloading the filters and thus allowing much more water to be filtered before the filters must be backwashed.

Filtration – Clarified water enters the filters from the top. Gravity pulls the water down through the filters where it is collected in a drain system at the bottom of the unit. There are many different types of materials (media) used in filters. The most common being sand and gravel. Many conventional plants are now using granular activated carbon as the media of choice because it not only provides excellent mechanical filtration of particulate matter, but also removes organic compounds which can cause taste and odor problems.

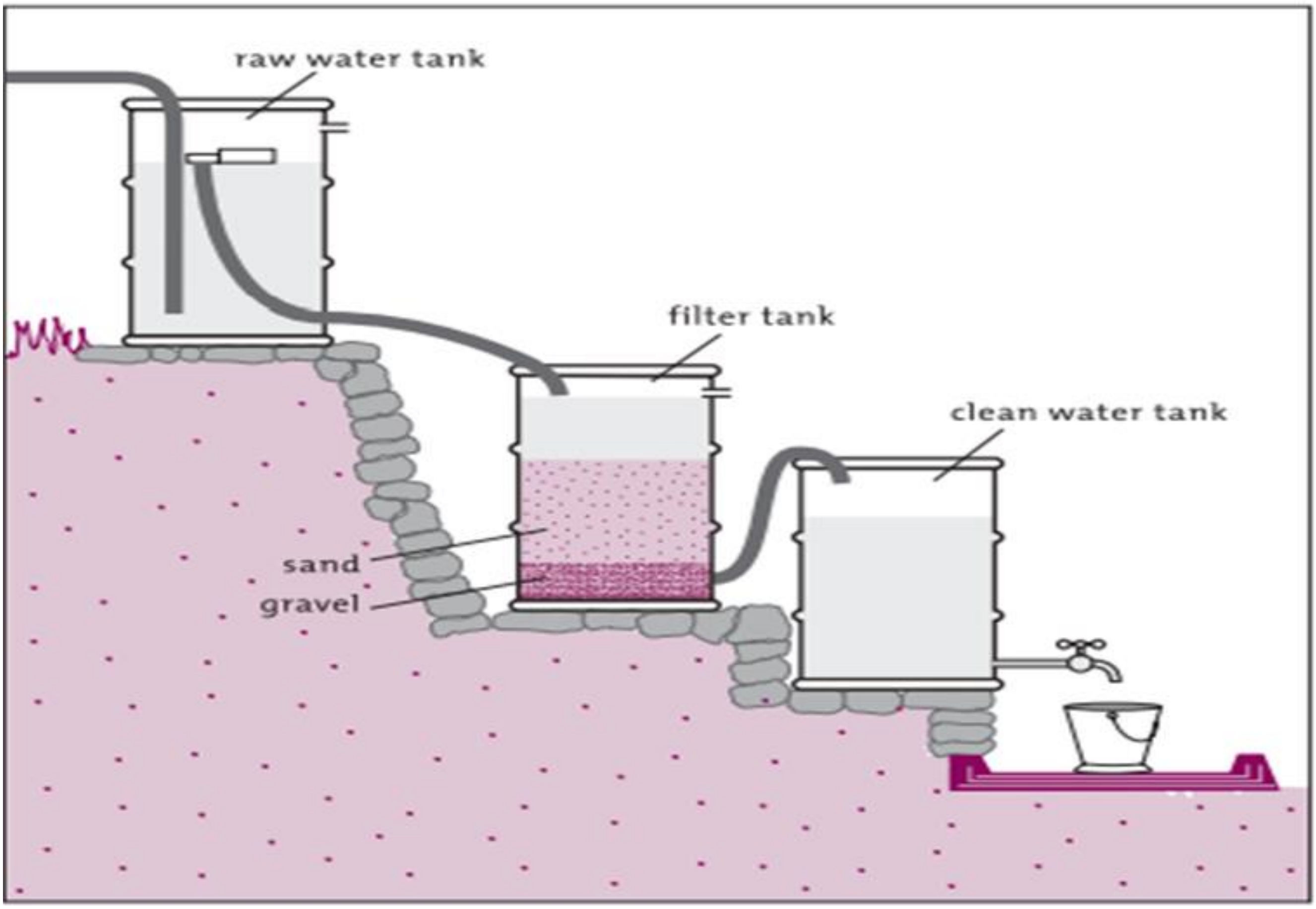

Figure 3.1. Household water flow and filtration processes

Disinfection – Once the water has gone through the filtration process, it is about as clear and clean as it can get. However, there may still be bacteria and viruses remaining. To ensure these are destroyed, there must be a disinfection process employed. The most common disinfection process used in the United States is chlorination. Chlorine comes in many different forms including chlorine gas (most common), chlorine dioxide, hypochlorite (bleach), and others. Whichever method is used, chlorine is added to the water in an amount to ensure all microorganisms are destroyed. Water plants monitor the chlorine levels continuously and very carefully in the treated water. They must add enough chlorine to ensure thorough disinfection of the water, but avoid adding excesses that can cause taste and odor problems when delivered to the consumer.

Water chlorination at household level1 Figure 3.1The technology Chlorination of water at household level can be used as an emergency measure or as part of everyday life. When water quality cannot be trusted, a carefully measured amount of concentrated chlorine solution is added to a container with a known amount of clear water. The mixture is stirred and left for at least 30 minutes, to let the chlorine react and oxidize any organic matter in the water. After this, the water is safe to drink. The amount of chlorine needed depends mainly on the concentration of organic matter in the water and has to be determined for each situation. After 30 minutes, the residual concentration of active chlorine in the water should be between 0.2–0.5 mg/l, which can be determined using a special test kit.

The concentrated chlorine solution can be made of clear water and chlorine-producing chemicals, such as bleaching powder, sodium hypochlorite, or organic chlorine tablets. It can be prepared at household level, but also in larger quantities and distributed among the households. A concentrated chlorine solution should be used within a relatively short time (defined according to the compound used) before it loses its strength. In some cases, chlorine-producing chemicals are added directly added to the water, without prior dilution. Some chlorine products come in combination with a flocculant to help settle suspended material in the water.

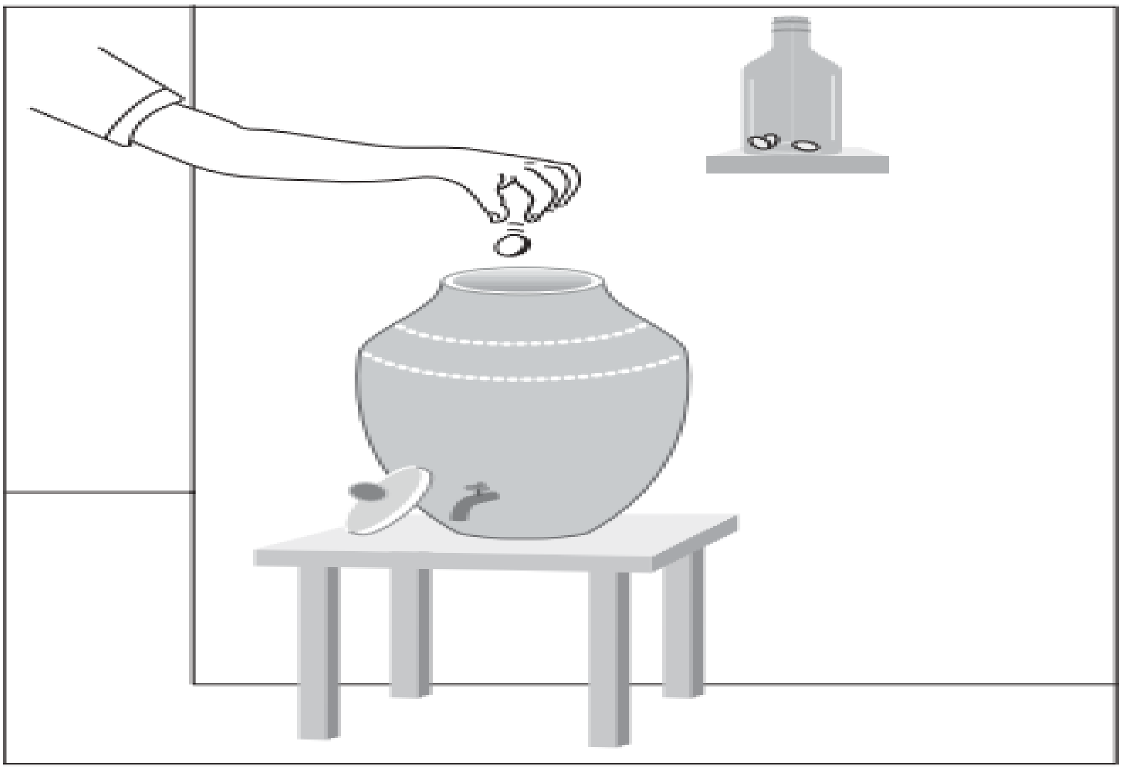

Figure 3.2.domestic chlorination using chlorine table at Household water Disinfection processes.

Storage – Once the disinfection process is complete, the water is stored. Storage usually takes place in an underground storage tank called a “clear well”, and also in elevated storage tanks that are visible around town. There must always be an ample supply of water available in the event of emergencies. These can include power outages, fires, floods, etc.

Chlorination in piped systems1, the technology Chlorination is a chemical method for disinfecting water. The chlorine inactivates pathogens in the water and provides a barrier against recontamination. It is normally applied at the last stage of a drinking-water treatment process. The most frequently used low-cost technology methods are batch chlorination and flow chlorination. For batch chlorination, a concentrated chlorine solution is added to the water in a reservoir, with both inlets and outlets closed. The water is stirred and the chlorine is left to react for at least 30 minutes. After that, the outlets can be opened. When the reservoir is empty, the outlets are closed and the reservoir is refilled with a new batch of water to be disinfected. Flow chlorinators continuously feed small quantities of a weak chlorine solution to a flow of fresh water, often at the inlet of a clear-water reservoir. Usually, a small reservoir containing the chlorine solution is placed on top of the water reservoir and the solution is administered close to the point where fresh water comes in, and turbulence guarantees good mixing. A special device, such as the floating bowl chlorinator, enables precise dosage. Sometimes a special electric pump is used for this purpose. Electrical devices that convert a solution of kitchen salt to active chlorine can be purchased for on-site chlorine production. Small test kits are also available for monitoring and for adjusting chlorine doses to the water quality and quantity. Chlorine-producing compounds must always be stored and prepared with care

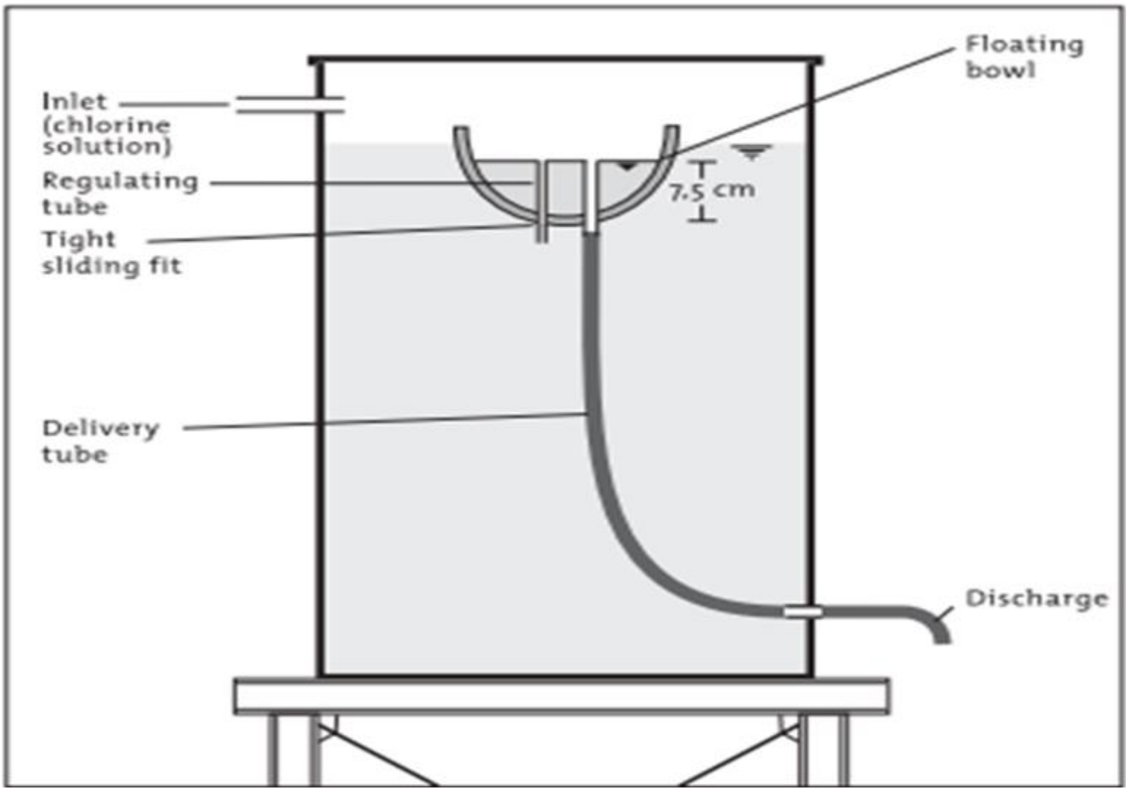

Figure 3.3. Floating bowl chlorination

Storage and sedimentation1 the technology The quality of raw water can be improved considerably by storage. During storage, non-colloidal, suspended particles slowly settle to the bottom of a storage tank, and solar radiation will kill some of the harmful organisms in the water. Schistosoma larvae, for example, will die after storage for at least 48 hours. In contrast, colloidal particles remain in suspension. The smaller the suspended particles, the longer the water needs to be retained in the reservoir. If the suspended matter precipitates very slowly, chemicals can be added to induce coagulation and flocculation. The reservoir can be constructed in several ways: — below ground level, with a lining of plastic sheeting to separate the stored water from the ground; — with a lining of loam, clay or concrete; — entirely from brick or concrete. Reservoirs for sedimentation usually have two separate sections. While one is in use, the other can be cleaned. They have an intake on one side of the reservoir (or at the bottom), an outlet on the opposite side just beneath the water level, and a bottom outlet to flush the deposited material. When the water quantity or quality at the source is temporarily low, a large storage reservoir can also provide an alternative temporary source of water.

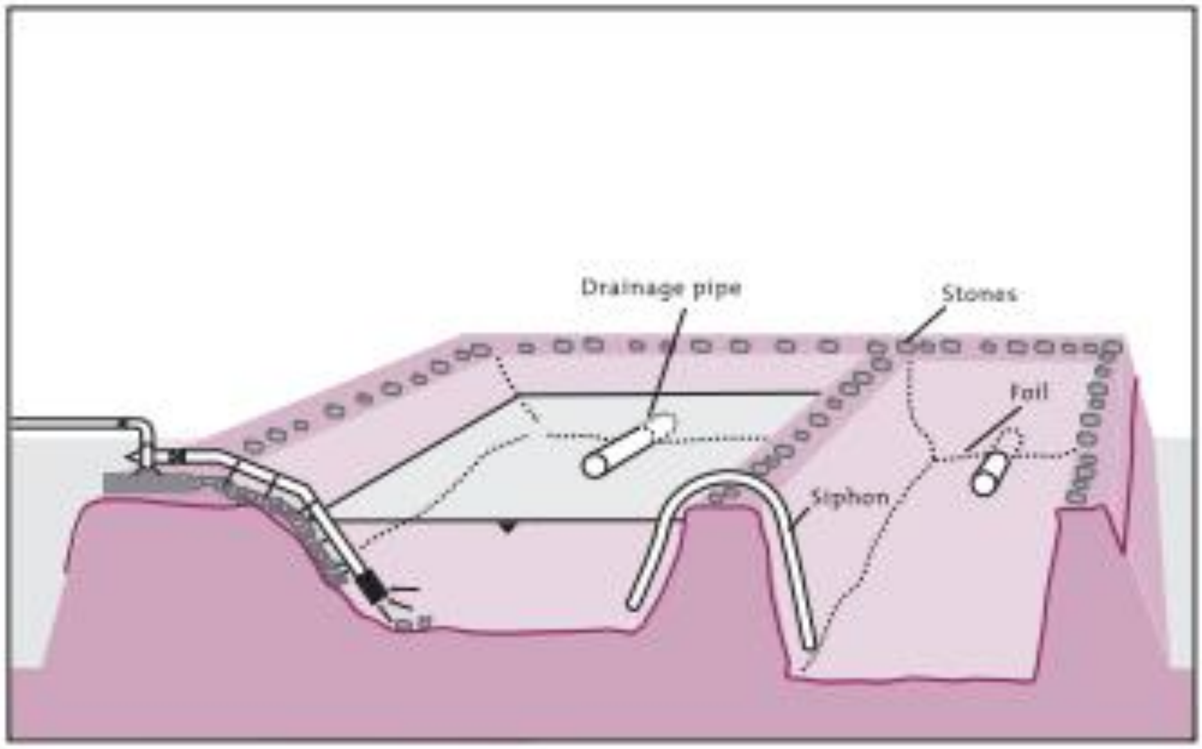

Figure 3.4. Storage and sedimentation processes

Slow sand filtration1: the technology The treatment of water by slow sand filtration combines biological, chemical and physical processes when the water slowly passes downwards through a bed of sand. Fine particles are filtered out, and in the sand and on top of the filter bed a population of microorganisms develops that feed on bacteria, viruses and organic matter in the water. The filter reservoirs have drains on the bottom covered with gravel and sand. Raw water slowly enters the filter through an inlet, and an outlet leads the clean water from the drains to the clean-water mains. During operation, the sand filter is covered with a water layer of 0.3–1.0 m. For the filter to work well, water must flow continuously at a rate of 0.1–0.3 m/hour. For community use, filter reservoirs can be made of concrete, bricks, ferrocement, etc. At least two filters are needed if clean water is to be provided continuously. When the quality of the raw water is poor, it is recommended that pretreatment steps be added (e.g. up flow roughing filter). Sometimes, the water is chlorinated after filtration to prevent recontamination. With good O&M, a slow sand filter produces water virtually free of harmful organisms. For the small-scale application of this method, see section Household slow sand filter.

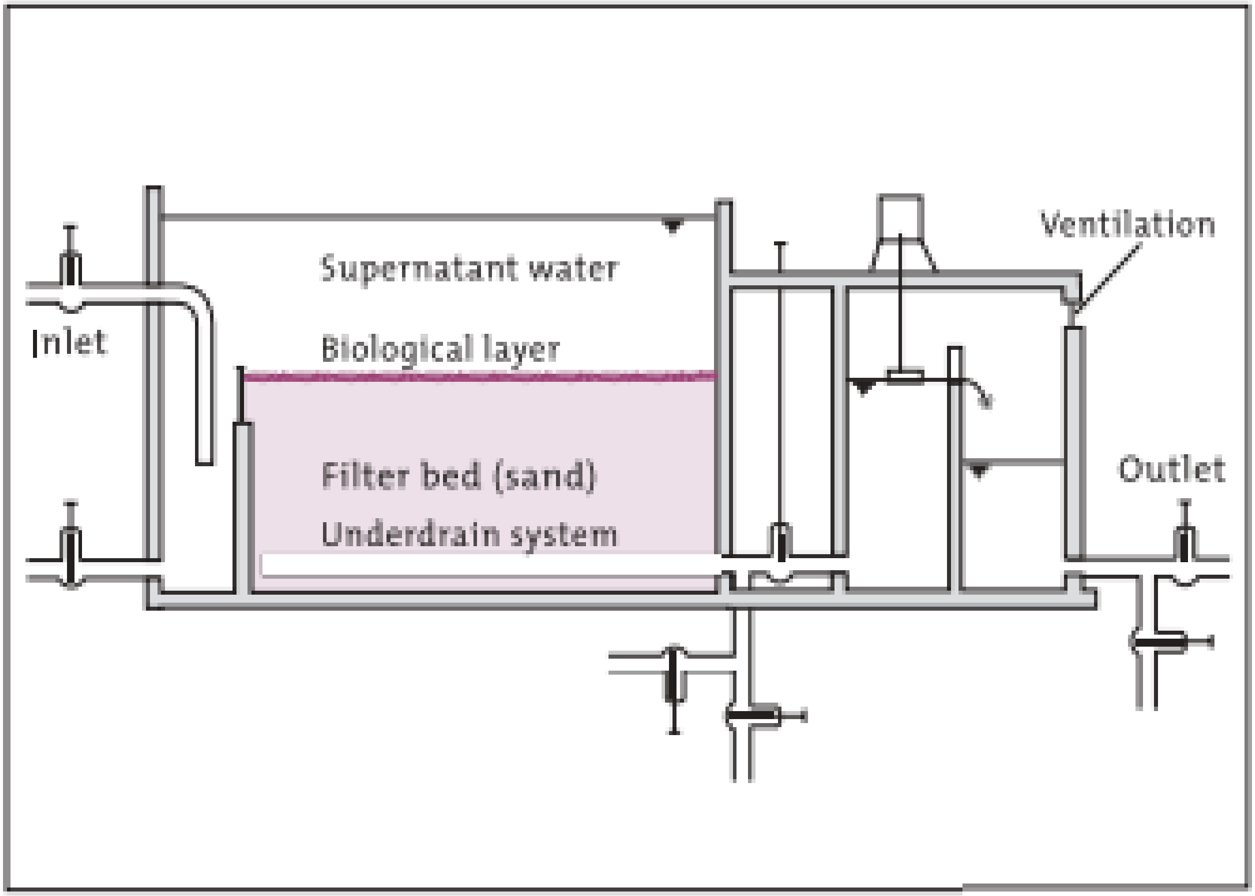

Figure 3.5. Slow sand filtration processes

Distribution – So how does the water come out of your kitchen tap? The stored water is pushed through underground pipelines all over town in what is called a "distribution system". The distribution system consists of large water pumps at the treatment plant, overhead water storage tanks, large pipelines, smaller pipelines, fire hydrants, valves, and water meters in your front yard.

Several processes are at your disposal for implementing the various preparation stages of water treatment:

- ✓ Physical processes for mechanical preparation such as aeration, sedimentation or thermal influence. This also includes the use of screens, filters and sieves.
- ✓ Biological processes such as anaerobic wastewater treatment, biochemical oxidation or
- ✓ Chemical processes such as neutralization, disinfection, flocculation and precipitation
- ✓ Membrane processes such as filtration, osmosis and nanofiltration

By nature, water is known to be pure as it is composed of strongly bonded atoms of hydrogen and oxygen. However, the water supply across the globe has to share space with other things such as organic materials, minerals, chemicals and manmade pollutants. This brings about an undrinkable solution, since it can contain deadly bacteria and viruses, among other disease-causing agents. Luckily, mankind was able to develop different water treatment methods to allow our water supply to be safe to drink. While there are some methods that are not effective on a larger scale, all of them make untreated water potable for human consumption.

The process of treating water may have slight differences at various locations, based on the plant's technology as well as the type of water that needs to be treated. Nevertheless, the basic principles are the same. The following section talks about the standard processes of water treatment.

- **Coagulation / Flocculation**

Coagulation is adding liquid aluminum sulfate or alum and/or polymer to raw or untreated water. The resulting mixture causes the dirt particles in the water to coagulate or stick together. Then, the groups of dirt particles attach together, forming larger particles named flocs that can easily be removed via filtration or settling.

- **Sedimentation**

When water and flocs undergo the treatment process, they go into sedimentation basins. Here, water moves slowly, making the heavy floc particles settle to the bottom. Floc that accumulates on the bottom is known as sludge. This is carried on to drying lagoons. Direct Filtration does not include the sedimentation step and the floc is just removed by filtration.

- **Filtration**

In filtration, water passes through a filter, which is made to take away particles from the water. Such filters are composed of gravel and sand or sometimes crushed anthracite. Filtration gathers together impurities that float on water and boosts the effectiveness of disinfection. Filters are regularly cleaned by means of backwashing.

- **Disinfection**

Before water goes into the distribution system, it is disinfected to get rid of disease-causing bacteria, parasites and viruses. Chlorine is also applied since it is very effective.

- **Sludge Drying**

Solids that have been gathered and removed from water via sedimentation and filtration are transferred to drying lagoons.

- **Fluoridation**

Fluoridation treats water supplies of communities to adjust the concentration of free fluoride ions to an optimal level so that dental cavities can be reduced. It is compulsory for Hunter Water to perform water fluoridation to conform to the NSW Fluoridation of Public Water Supplies Act 1957.

- **PH Correction**

To adjust pH levels, lime is combined with filtered water. This, also, stabilizes naturally soft water so corrosion can be minimized in the water distribution system and plumbing of customers.

Self-Check -1	Written Test

Direction I: Multiple choice item (2 points each)

Instruction I: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. Water treatment is any process that improves the quality of water to make it appropriate for a specific end-use A. True B. false.
2. The water treatment process may vary slightly at different locations, depending on
   A. the technology of the plant
   B. the water it needs to process
   C. types of water
   D. all.

3. water treatment process typically consist of several steps in the treatment process. These include:
   A. ------------------------
   B. ----------------------
   C. ----------------------
   D. --------------------
   E. ----------------------
   F. ---------------------
   G. --------------------
   H. ------------------
   I. ---------------------
4. Physical processes for mechanical preparation such as aeration, sedimentation or thermal influence. A. True. B. False.
5. Biological processes such as anaerobic wastewater treatment, biochemical oxidation or sludge digestion A. True. B false.
6. Chemical processes such as neutralization, disinfection, flocculation and precipitation

   A. True. B. false.

7. Membrane processes such as filtration, osmosis and nanofiltration

   A. True. B. false.
8. The process of treating water may have slight differences at various locations, based on the plant's technology as well as the type of water that needs to be treated
   A. True. B. false.

Note: **Satisfactory rating - 10 points and above Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet 1

Score = ___________
Rating: ____________

Name: _________________________

Date: _______________

1._____, 2. _______, 3. _______, 4. ______.5_____, 6. _______, 7. _______, 8. ______

2.1. Introduction Appropriate sampling and testing

A sampling plan is a detailed outline of which measurements will be taken at what times, on which material, in what manner, and by whom. Sampling plans should be designed in such a way that the resulting data will contain a representative sample of the parameters of interest and allow for all questions, as stated in the goals, to be answered.

The accuracy of water quality results obtained in the laboratory is just as dependent on the correctness of the sampling technique as it is dependent on the accuracy of the analytical procedures. Therefore the sampling exercise requires careful planning beforehand.

Before any sampling program is started, it is important to define clearly the objectives of the

Sampling program as this will dictate issues such as:

- ✓ The substances to be sampled and analyzed
- ✓ The frequency of sampling
- ✓ The choice of preparatory steps prior to analyses
- ✓ The appropriate guidelines to evaluate the results.
- ✓ Which substances in the water are of interest
- ✓ Where and when are samples to be taken
- ✓ how are samples to be taken
- ✓ Which analytical methods are to be used
- ✓ How results are to be reported; and
- ✓ What is to be done with the reported results.

- **Types and purpose of water samples**

The two types of water samples typically to be taken are grab samples and composite samples. Grab samples are usually taken when you want information specific to a particular sampling location, time or distinct areas within a sampling location.

Composite samples are usually taken when we want an average representation of a sampling location or time. For example, if we want to know how water chemistry varies within a lake, then we will take a number of grab samples. If we don't care how the chemistry varies within the lake, but just want to know the "average" water quality of the lake, we can take a composite sample from several locations.

A properly taken grab sample is a snap shot of the quality of the water at the exact time and place the sample was taken. Depending on the water body, grab samples may be taken by simply dipping a sample bottle in the water body, or they may require the use of specific sampling devices.

- ✓ **Grab Samples**

The simplest, a "grab" sample, is taken at a selected location, depth and time. Normally, the quantity of water taken is sufficient for all the physical and chemical analyses that will be done on the sample. Sometimes, if the sampler is small and many analyses are to be done, two grab samples will be taken at the station and will be mixed in the same transport container. Grab samples are also known as "spot" or "snap" samples.

There are two types of grab samples that are used for sampling water matrices: discrete and depth-integrated.

The ***discreet*** grab sample is one that is taken at a selected location, depth, and time and then analyzed for the constituents of interest.

A ***depth-Integrated*** grab Sample is collected over a predetermined part or the entire depth of the water column, at a selected location and time, in a given body of water, and then analyzed for the constituents of interest.

The primary advantage of grab samples is that sometimes very little equipment is required for sample collection and there is flexibility in sampling location selection. However, this method sacrifices data resolution because of the smaller number of samples that are usually collected

- ✓ **Composite samples**

A composite sample is a mixture of grab samples taken at different times or locations and pooled together to provide one sample. Composite samples may be of the following types:

- ✓ **Area-integrated**: made by combining a series of samples taken at various sampling points spatially distributed in the water body (but usually all at one depth or at predetermined depth intervals).
- ✓ **Time-integrated**: made by mixing equal volumes of water collected at a sampling station at regular time intervals.
- ✓ **Discharge-integrated**: It is first necessary to collect samples and to measure the rate of discharge at regular intervals over the period of interest. A common arrangement is to sample every 2 hours over a 24-hour period. The composite sample is then made by mixing portions of the individual sample that are proportional to the rate of discharge at the time the sample was taken
- ✓ **Depth-integrated**: most commonly made up of two or more equal parts collected at predetermined depth intervals between the surface and the bottom. A piece of flexible plastic piping of several meters in length, and which is weighted at the bottom, provides a simple mechanism for collecting and integrating a water sample from the surface to the required depth in a lake.

- **Advantages and Disadvantages of Composite Samples**

Advantages of composite samples include reduced costs of analyzing a large number of samples, more representative samples of heterogeneous matrices, and larger sample sizes when amounts of test samples are limited.

It also gives you an idea of the average condition of a water body over time, (samples taken at different times and mixed together) or space, (samples taken at different locations within the water body). This is particularly useful in water bodies that have a lot of chemical variability either over space or over short time periods. Composite samples are often used to reduce the cost of analyzing a large number of samples

Disadvantages of composite samples include loss of analyte relationships in individual samples, potential dilution of analytes below detection levels, increased potential analytical interferences, and increased possibility of analyte interaction.

- **Methods of Sampling**
  - ✓ **Manual Sampling**:

Manual sampling involves minimal equipment but may be unduly costly and time-consuming for routine or large-scale sampling programs. It requires trained field technicians and is often necessary for regulatory and research investigations for which critical appraisal of field conditions and complex sample collection techniques are essential.

  - ✓ **Automatic sampling**:

Automatic samplers can eliminate human errors in manual sampling, can reduce labor costs, may provide the means for more frequent sampling and are used increasingly. Be sure that the automatic sampler does not contaminate the sample.

- **Sampling Locations**

Water samples are collected from locations which are representative of the water source.

Locations for collecting water sampling can be described as:

- ✓ **Raw water supply** which includes surface water and ground *water* supply.
- ✓ **Surface Water supply**: Surface water sources are divided into flowing and standing water. The sampling frequency at these two types of water resources differs. Rivers and streams are more susceptible to sudden water quality changes than lakes and dams.

  Thus, more frequent samples are needed from a river or stream than from a lake or dam. Surface water supply sources include rivers, streams and lakes.

- **Groundwater supply**:

  Ground water is a type of water found in the ground seeps down through the soil until it reaches rock material that is saturated with water. Water in the ground is stored in the spaces between rock particles. This type of water can be used for taking water samples.

- ✓ **Water distribution and treatment systems.**

Are ways of controlling the flow and direction of both surface and ground water**.** They are the link between the water supply source and the consumer.

Water samples are taken at the outlet of treatment works to check the treatment processes and/or the quality of the water supplied to the consumer.

Water within a distribution system is normally sampled to evaluate and check whether the distribution system performs correctly. If overall performance of the distribution system needs to be evaluated it is better to take the sample from a pipe with significant flow, rather than from a stagnant section of the distribution system. For contamination, monitoring samples must be collected down-flow of the (suspected) point of contamination in the distribution system.

- **Safety Precautions for Water Sampling**

While safety is often not considered an integral part of the sampling program, the sampler must be aware of possible unsafe working conditions, hazards associated with the operation of sampling gear, and other risks.

Basic good practice should be followed in the field. Always keep the following points in mind –

- ✓ Wear appropriate PPE
- ✓ Never drink the water you are about to sample unless you are very sure about the quality and safety of the water.
- ✓ Many hazards lie out of sight on the bottom of dams, rivers and streams. Broken glass or sharp pieces of metal embedded into the substrate can cause serious injury if care is not exercised when working in such environments**.**
- ✓ A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling.
- ✓ The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- ✓ Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.
- ✓ Samplers must use new, verified and certified-clean disposable or non-disposable equipment cleaned according to work operating procedures
- ✓ Maintain decontamination and contamination free zones properly
- ✓ Contain all contaminated PPE and sampling equipment for disposal or decontamination.

- **Rules of Sampling**

In taking water samples from different sources take extra care to avoid contaminating the sample container and water sample.

Do not:

- ✓ Contaminate the bottle by touching the inside of the bottle.
- ✓ Contaminate the bottle lid by touching the inside rim.

- ✓ Put the bottle lid on the ground while sampling.
- ✓ Transport aquatic facility water samples with other water samples, e.g. effluent or drinking water**.**

Always:

- ✓ Collect microbiological samples before collecting other samples.
- ✓ Label the bottle before sampling.
- ✓ Discard damaged or contaminated bottles. If in doubt throw it out and take sample in a new bottle.
- ✓ Wash your hands thoroughly before and collecting samples.

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth (2pt each)

1. Which step is considered developing sampling plan?

A. Selecting sampling size B. Identifying of parameters
C. Design of sampling scheme D. All

2. Which one of these is **not** a disadvantage of composite samples?

A. Loss of analyze relationships in individual samples

B. Reduced costs of analyzing of samples

C. potential dilution of analyzes below detection levels

D. Increase the possibility of analyte interaction.

3-------------- is a type of sample usually taken when you want information specific to a particular sampling location, time or distinct areas within a sampling location:

A. Composite sample B. Grab sample C. Analyses D. All

4. Types of samples usually taken when we want an average representation of a sampling location or time are

A. Grab sample B. Composite sample C. Discreet grab sample

5. A properly taken grab sample is a snap shot of the quality of the water at the exact time and place the sample was taken. A True B/ False

Note: **Satisfactory rating - 8 points** **Unsatisfactory - below 5points**

Answer Sheet-2

Name: ___________________________ Date: ________________

Choice Questions

Score = ___________

1_________ 2.________ 3.________4..________5 ________

Operation Sheet -1	Identifying optimum treatment processes for microorganisms in water sources

Steps to Identifying optimum treatment processes for microorganisms in water sources

1. Identifying tools and equipment's
2. Inspecting water source
3. Recording the inspected data
4. Identify appropriate methods of waste control processes.
5. Check the functionality and effective ness
6. Organizing and Report the data

Operation Sheet -2	Maintaining water quality appropriate sampling and testing

Steps to Maintaining water quality by appropriate sampling and testing

1. Identifying tools and equipment's
2. Inspecting water source
3. Recording the inspected data
4. Identify appropriate methods.
5. Check the functionality and effectiveness
6. Organizing and Report the data
7. Evaluate the results.

LAP Test	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: __________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to Select Water Treatment Requirements for Waterborne within 6 hr.

Task1. Identifying optimum treatment processes for microorganisms in water sources.

Task 2. **Maintaining water quality by appropriate sampling and testing**

List of Reference Materials

1. USEPA. 2009. *Long Term 2 Enhanced Surface Water Treatment Rule, Toolbox Guidance Manual Review Draft*. Go into http://www.epa.gov/safewater/disinfection/lt2/ and then enter: toolbox guidance manual review draft in the 'search' box. See USEPA (2010) for Final.
2. USEPA. 2010. *Long Term 2 Enhanced Surface Water Treatment Rule, Toolbox Guidance Manual*. EPA-815-R-09-016. 375 pp. http://www.epa.gov/safewater/disinfection/lt2/pdfs/guide_lt2_toolboxguidancemanual.pdf.
3. WHO. 2004a. *Water Treatment and Pathogen Control: Process efficiency in achieving safe drinking water*. MW LeChevallier, K-K Au. IWA Publishing. 136 pp. Available at: www.who.int/water_sanitation_health/publications/en/index.html..
4. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), Drinking Water https://bit.ly/2RpwjXQ .
5. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), *Rural and urban drinking water service levels (2000 and 2015)* https://bit.ly/2DGJtfn
6. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)*, Sanitation (rural and urban 200 and 2015)* https://bit.ly/2HGfbNV
7. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), *Open Defecation (rural and urban 2000 and 2015)* https://bit.ly/2FW3j90
8. United Nations Inter-agency Group (UNICEF) for Child Mortality Estimation (UN IGME) 2018, *Under-five mortality*, updated March 2018 https://bit.ly/2h45GcT
9. EPA, Environmental Protection Agency, USA, "Recommendations to Improve Security at Drinking Water Facilities" 2001 http://www.lgean.org/html/whatsnew.cfm?id
10. Greater Vancouver Regional District Drinking Water Treatment Program, "Best Management Practice for Pigging and Flushing Water Mains" 1997 http://www.gvrd.bc.ca/services/water/chlorlin/flushing.pd