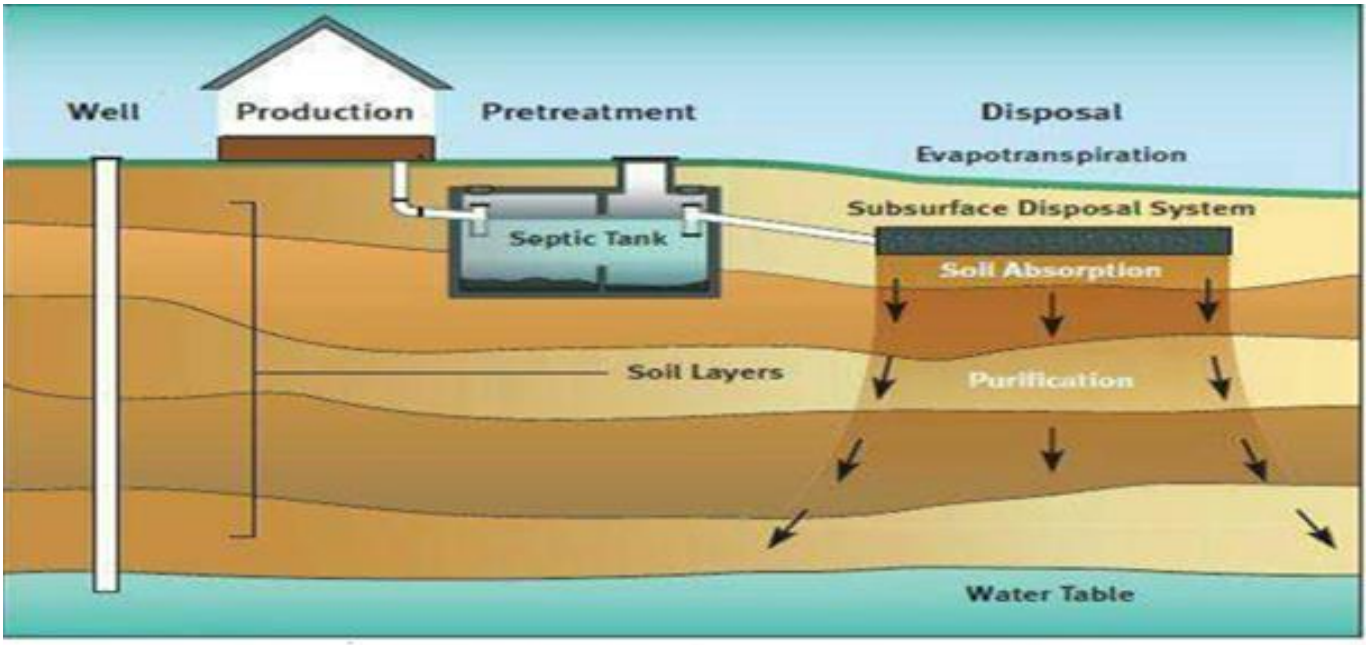
ENGINEERING TECHNOLOGY

Civil Engineering Department

Environmental Quality Engineering Section



Influence of septic waste on the environment.

Complied by,
Emmanuel Yaw Botchway

Environmental Engineering is basically the application of theories of science and material forces to confront ecological and socio-economic problems

Environment is the sum total of all surroundings of a living organism, including natural forces and other living things, which provide conditions for development and growth as well as of danger and damage

Sources of water includes Ground and underground

In **septic** systems, wastewater drains from toilets and sinks into an underground **tank**, then through porous pipes in a leach field, where surrounding sand filters out bacteria and other pathogens. ... "As a result, untreated sewage can end up polluting nearby **groundwater**.

Infiltration is the process by which **water** on the ground surface enters the **soil**. ... **Infiltration** rate in **soil** science is a measure of the rate at which a particular **soil** is able to absorb rainfall or irrigation. It is measured in inches per hour or millimeters per hour. The rate decreases as the **soil** becomes saturated.

Wastewater is any water that has been contaminated by human use. It is used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff or stormwater, and any sewer inflow or sewer.

Types of wastewater include: domestic **wastewater** from households, municipal **wastewater** from communities (also called **sewage**) and industrial **wastewater**. **Wastewater** can contain physical, chemical and biological pollutants.

Wastewater treatment is the **process** of converting **wastewater** back into the environment. It's formed by a number of activities including bathing, washing, using the toilet, and rainwater runoff.

Sewage treatment is the process of removing contaminants from municipal wastewater, containing mainly household sewage plus some industrial wastewater. Physical, chemical, and biological processes are used to remove contaminants and produce treated wastewater that is safe enough for release into the environment.

Pollution can be defined as an undesirable change in the physical, chemical or biological characteristics of the air water or land that can harmfully affect health and survival of living and non-living organisms

Four common ways to treat wastewater include

Physical Water **Treatment**,

Biological Water **Treatment**,

Chemical **Treatment**,

Sludge **Treatment**

BASIC ANALYTICAL PARAMETERS USED IN RESEARCH

Benchtop Conductivity Meter

Dissolved Oxygen Monitor

Instruments Uses and Principle

1. pH Meter

- pH meter is a device used in laboratories that measure the H-ion concentration in water-based solutions to determine the acidity or alkalinity of the solution.
- A pH meter is often termed as “potentiometric pH meter” as it measures the difference in electric potential between the reference and a pH electrode.

Working Principle

- In a potentiometric pH meter, single or multiple glass electrodes, connected to a bulb selective to hydrogen ions, are attached to a metal rod.
- When the bulb with the electrodes is dipped into a solution, hydrogen ions in the solution exchange with positive charges on the electrode generating an electrochemical potential which is displayed in terms of pH units on display.

Uses

- A pH meter is primarily used to measure the acidity of pharmaceutical chemicals, cultures, soil, and water treatment plant.
- It can be used to measure the acidity level in wine and cheese during their production.

2: Spectrophotometry

Spectrophotometry is a method to measure how much a chemical substance absorbs light by measuring the intensity of light as a beam of light passes through sample solution. The basic principle is that each compound absorbs or transmits light over a certain range of wavelength. This measurement can also be used to measure the amount of a known chemical substance. Spectrophotometry is one of the most useful methods of quantitative analysis in various fields such as chemistry, physics, biochemistry, material and chemical engineering and clinical applications.

Introduction

Every chemical compound absorbs, transmits, or reflects light (electromagnetic radiation) over a certain range of wavelength. Spectrophotometry is a measurement of how much a chemical substance absorbs or transmits. Spectrophotometry is widely used for quantitative analysis in various areas (e.g., chemistry, physics, biology, biochemistry, material and chemical engineering, clinical applications, industrial applications, etc). Any application that deals with chemical substances or materials can use this technique. In biochemistry, for example, it is used to determine enzyme-catalyzed reactions. In clinical applications, it is used to examine blood or tissues for clinical diagnosis. There are also several variations of the spectrophotometry such as atomic absorption spectrophotometry and atomic emission spectrophotometry.

A spectrophotometer is an instrument that measures the amount of photons (the intensity of light) absorbed after it passes through sample solution. With the spectrophotometer, the amount of a known chemical substance (concentrations) can also be determined by measuring the intensity of light detected. Depending on the range of wavelength of light source, it can be classified into two different types:

- **UV-visible spectrophotometer**: uses light over the ultraviolet range (185 - 400 nm) and visible range (400 - 700 nm) of electromagnetic radiation spectrum.

- **IR spectrophotometer**: uses light over the infrared range (700 - 15000 nm) of electromagnetic radiation spectrum.

In visible spectrophotometry, the absorption or the transmission of a certain substance can be determined by the observed color. For instance, a solution sample that absorbs light over all visible ranges (i.e., transmits none of visible wavelengths) appears black in theory. On the other hand, if all visible wavelengths are transmitted (i.e., absorbs nothing), the solution sample appears white. If a solution sample absorbs red light (~700 nm), it appears green because green is the complementary color of red. Visible spectrophotometers, in practice, use a prism to narrow down a certain range of wavelength (to filter out other wavelengths) so that the particular beam of light is passed through a solution sample.

Devices and mechanism

Figure 1 illustrates the basic structure of spectrophotometers. It consists of a light source, a collimator, a monochromator, a wavelength selector, a cuvette for sample solution, a photoelectric detector, and a digital display or a meter. Detailed mechanism is described below. Figure 2 shows a sample spectrophotometer (Model: Spectronic 20D).

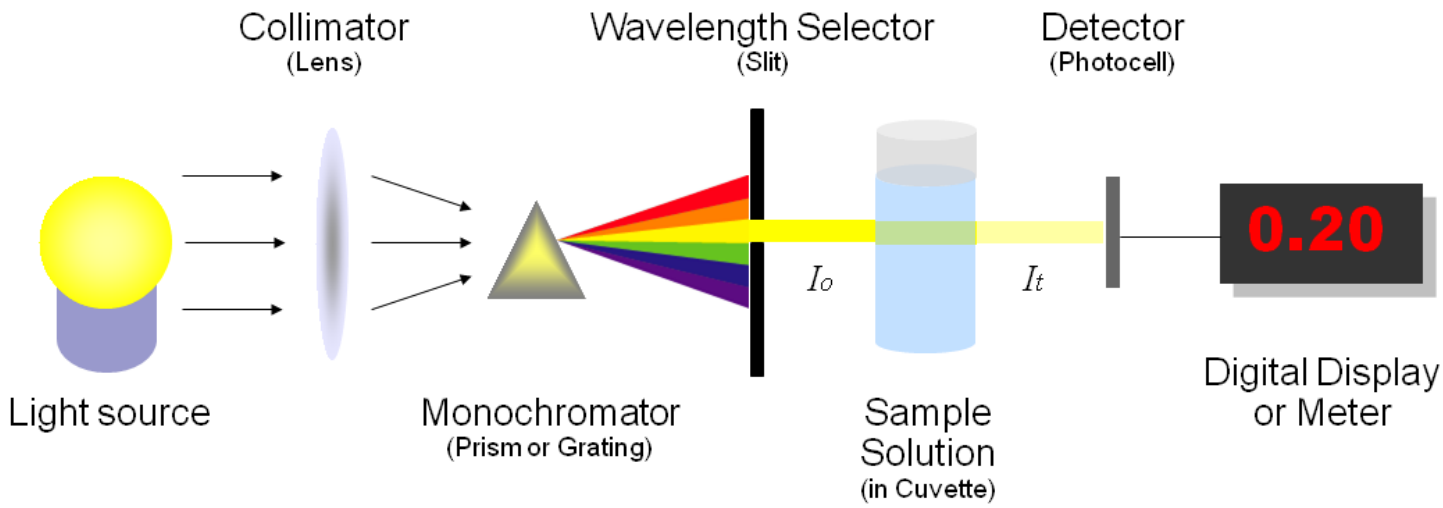


Figure 1: Basic structure of spectrophotometers (illustrated by Heesung Shim)

A spectrophotometer, in general, consists of two devices; a spectrometer and a photometer. A spectrometer is a device that produces, typically disperses and measures light. A photometer indicates the photoelectric detector that measures the intensity of light.

- **Spectrometer**: It produces a desired range of wavelength of light. First a collimator (lens) transmits a straight beam of light (photons) that passes through a monochromator (prism) to split it into several component wavelengths (spectrum). Then a wavelength selector (slit) transmits only the desired wavelengths, as shown in Figure 1.
- **Photometer**: After the desired range of wavelength of light passes through the solution of a sample in cuvette, the photometer detects the amount of photons that is absorbed and then sends a signal to a galvanometer or a digital display, as illustrated in Figure 1.

Figure 2: A single wavelenth spectrophotometer

You need a spectrometer to produce a variety of wavelengths because different compounds absorb best at different wavelengths. For example, p-nitrophenol (acid form) has the maximum absorbance at approximately 320 nm and p-nitrophenolate (basic form) absorb best at 400nm, as shown in Figure 3.

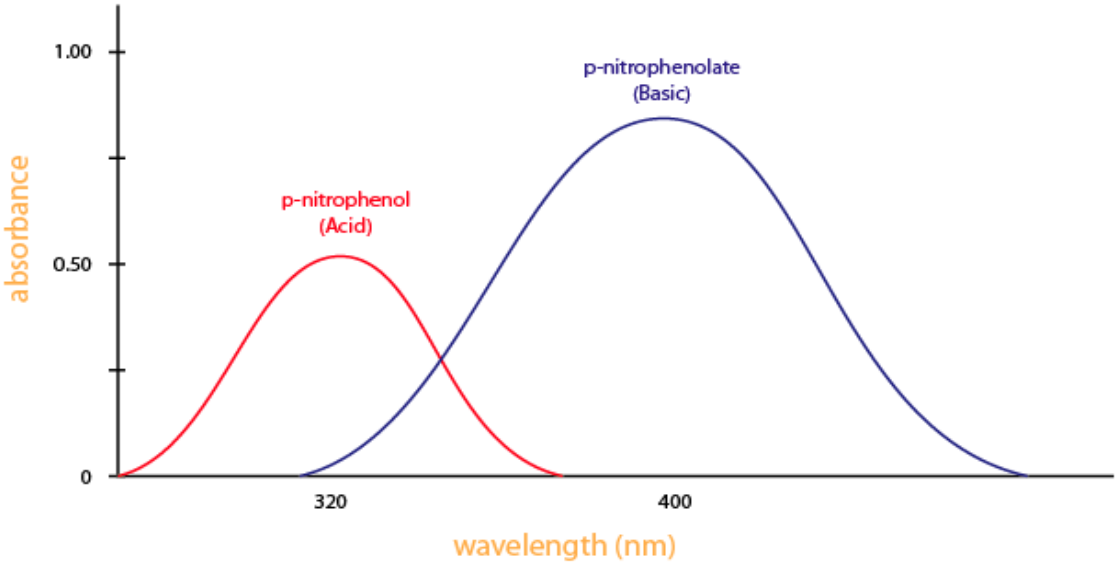


Figure 3: Absorbance of two different compounds

Looking at the graph that measures absorbance and wavelength, an isosbestic point can also be observed. An **isosbestic point** is the wavelength in which the absorbance of two or more species are the same. The appearance of an isosbestic point in a reaction demonstrates that an intermediate is NOT required to form a product from a reactant. Figure 4 shows an example of an isosbestic point.

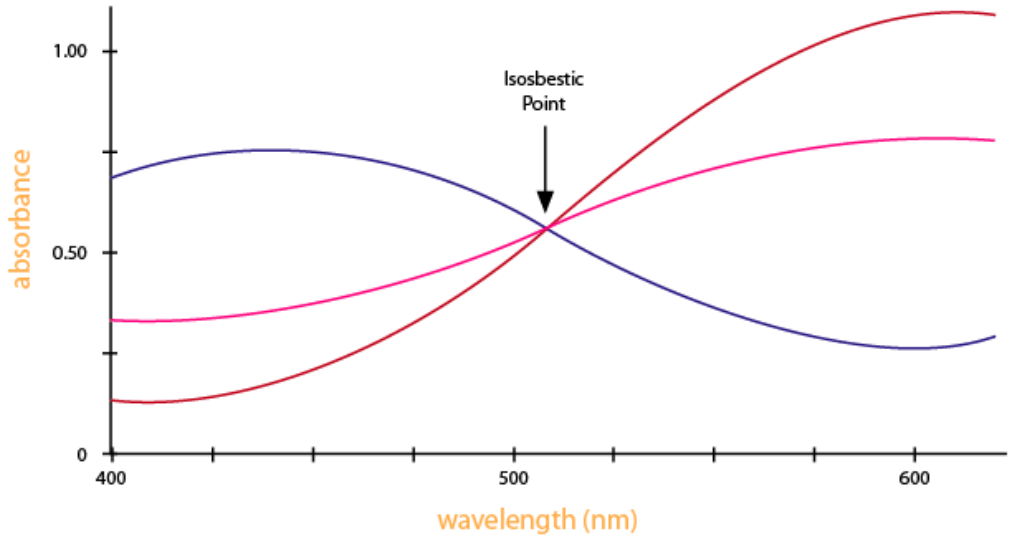


Figure 4: An example of isosbestic point

Referring back to Figure 1 (and Figure 5), the amount of photons that goes through the cuvette and into the detector is dependent on the length of the cuvette and the concentration of the sample. Once you know the intensity of light after it passes through the cuvette, you can relate it to transmittance (T). Transmittance is the fraction of light that passes through the sample. This can be calculated using the equation:

$$Transmittance(T)=I_tI_o$$

Where I_t is the light intensity after the beam of light passes through the cuvette and I_o is the light intensity before the beam of light passes through the cuvette. Transmittance is related to absorption by the expression:

$$Absorbance(A)=-log(T)=-log(I_tI_o)$$

Where absorbance stands for the amount of photons that is absorbed. With the amount of absorbance known from the above equation, you can determine the unknown concentration of the sample by using Beer-Lambert Law. Figure 5 illustrates transmittance of light through a sample. The length l

is used for Beer-Lambert Law described below.

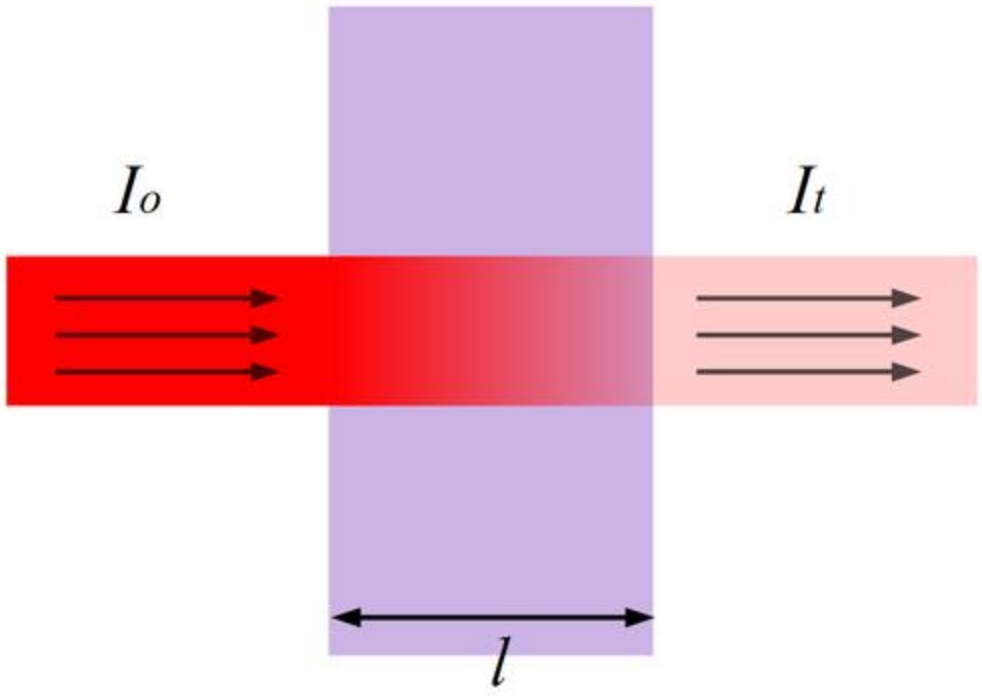


Figure 5: Transmittance (illustrated by Heesung Shim)

Beer-Lambert Law

Beer-Lambert Law (also known as Beer's Law) states that there is a linear relationship between the absorbance and the concentration of a sample. For this reason, Beer's Law can *only* be applied when there is a linear relationship. Beer's Law is written as:

$A=\epsilon lc$

where

- A

 is the measure of absorbance (no units),
 ϵ
 is the molar extinction coefficient or molar absorptivity (or absorption coefficient),
 l
 is the path length, and
 c

- is the concentration.

The molar extinction coefficient is given as a constant and varies for each molecule. Since absorbance does not carry any units, the units for ϵ
must cancel out the units of length and concentration. As a result, ϵ has the units: $L \cdot mol^{-1} \cdot cm^{-1}$. The path length is measured in centimeters. Because a standard spectrometer uses a cuvette that is 1 cm in width, l is always assumed to equal 1 cm. Since absorption, ϵ, and path length are known, we can calculate the concentration c

of the sample.

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2. Spectrophotometer

- The spectrophotometer is an optical instrument for measuring the intensity of light in relation to the wavelength.
- Based on the amount of light absorbed by a colored solution, a quantitative analysis of the solution can be done.

Working Principle

- Spectrophotometry is based on the Beer-Lambert Law, which states the absorbance of light by a solution (of a particular wavelength) is directly proportional to the concentration of the substance.
- Different wavelengths of lights are passed through a solution as different substances have better absorbance at different wavelengths. Based on the absorbance of a particular wavelength, the quantitative analysis of a solution can be done.

Uses

- In a microbiology laboratory, a spectrophotometer is applied for the measurement of substance concentration of protein, nucleic acids, bacterial growth, and enzymatic reactions.

3. Vortex Mixture/ Vortexer

- A vortex mixture is one of the basic technologies used for the mixing of samples in glass tubes or flasks in laboratories.

Working Principle

- It is based on the simple principle of causing reactions and homogenization by agitating the mixture.
- Motorized draft shafts present on the mixer oscillates and transfers the movement to the sample tubes causing the sample fluids to undergo turbulent flow.

Uses

- Vortex mixer is mostly used for the mixing of various sample fluids in the sample tubes and also allows for the homogenization of cells and cell organelles.

4. Water Bath

- Water Bath is a conventional device that is used for chemical reactions that required a controlled environment at a constant temperature.

Working Principle

- A sensor in the device transfers water temperature to a reference value which is then amplified and a control system generates a signal for the heating system which heats the water to the desired temperature.

Uses

- Water baths are primarily used for heating samples under a controlled temperature.
- These are suitable for heating chemicals that might be flammable under direct ignition.

5. Homogenizer

- Homogenizer is a device used in laboratories for the mixing of various liquids and materials like tissue, plant, food, soil, and many others.

Working Principle

- This instrument is based on the principle that when large globules in coarse emulsion are passed under high pressure through a narrow orifice, they break down into smaller particles giving a more uniform and stable mixture.
- A homogenizer has a metal rod with narrow parallel openings in the form of a comb at the end which acts as the orifice for the homogenization process.

Uses

- A homogenizer is primarily used to disrupt cells to acquire cell organelles for different microbiological processes.
- It is used in the preparation step before the extraction and purification of different macromolecules like proteins, nucleic acids, and lipids.

6. Colony Counter

- A colony counter is used to estimate the density of a liquid culture by counting the number of CFU (colony forming units) on an agar or culture plates.

Working Principle

- This instrument can accommodate different sizes of plates which are scanned on top with UV, white light and/or fluorescent illumination.
- One can accomplish the counting either manually with the touch pressure or with a digital counter.

Uses

- A colony counter is primarily used for counting the number of colonies present on a culture plate to estimate the concentration of microorganisms in liquid culture.

7. Analytical Balance

- An analytical balance is a type of balance that is commonly used for the measurement of mass in the sub-milligram range.

Working Principle

- These types of balances are made with a measuring pan enclosed in a transparent covering that prevents smalls particles or air currents from getting collected on the pan.
- An electric analytical balance uses the force necessary to counteract the mass rather than measuring the mass itself.
- An electromagnet is used to create a force required to achieve a balance with the mass of the substance, and the resulting force is displayed.

Uses

- As they are highly precise and based on advanced technology, analytical balances are explicitly used in laboratories for the effective completion of tasks like weighing test materials and sampling amounts, formulation, density determination, purity analysis, quality control testing, and material and conformance testing.

Working Principle

- Autoclaves use steam as their sterilization agent. The basic principle of an autoclave is that all the items within the autoclave come in direct contact with the steam for a particular period irrespective of the nature of the material- whether it is liquid, plastic ware, or glassware.
- The amount of time and the temperature depends on the type of material being sterilized and the increase in temperature of the cycle allows for shorter periods.

Uses

- Autoclaves are mostly used for the sterilization of medical or laboratory equipment with the capacity of sterilizing a large number of materials at once.
- They are commonly used for the preparation of culture media during laboratory applications.

8. Centrifuge

- A centrifuge is a device that allows the rotation of an object about a single axis, where an outward force is applied perpendicularly to the axis.
- A laboratory centrifuge is motor-based and allows the rotation of a liquid sample resulting in the separation of the components of the mixture.

Working Principle

- A centrifuge works on the principle of sedimentation, where the high speed of the rotation causes the denser particles to move away from the center while smaller, less dense particles are forced towards the center.
- Thus, the denser particles settle at the bottom while the lighter particles are collected at the top.
- In a laboratory tabletop centrifuge, the sample tubes are aligned at an angle so that the particles have to travel a shorter distance before they hit the bottom.

Uses

- The primary application of a centrifuge is the separation of particles suspended in a suspension. It can be used for the separation of cell organelles, nucleic acid, blood components, and separation of isotopes.

9. Laminar Air Flow/ Laminar Hood

- Laminar Hood is a closed device primarily for processes or instruments sensitive to microbial contamination.

Working Principle

- A Laminar Hood is made up of stainless steel, avoiding joints and corners to prevent the accumulation of bacterial spores.

- This device creates a sterile environment with the flow of sterile air through a High-Efficiency Particulate Air (HEPA) filter and shortwave ultraviolet germicidal lamp that sterilizes the workstation.
- Laminar Air Flow has to turn on 15 minutes before to ensure complete sterilization and the workstation should be cleaned with ethanol before and after use.

Uses

- Laminar Hood is commonly used to conduct processes that are sensitive to contamination.
- It is used for experiments related to plant tissue culture and for the experiments of genetic transformation.

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10. Microscope

- Microscopes are devices that allow the observer to an exceedingly close view of minute particles.

Working Principle

- There are many different types of microscopes, each of which works on their respective principles. However, there is some commonality in them.
- The basic principle in a microscope is magnification. Based on the relative position of the object from the lens or electromagnets, different positions, nature, and magnification of the image can be achieved.
- Different types of microscopes are developed to cater to the specific needs of the observation. However, the common theme is magnification.

Uses

- Based on the type of microscopes, different microscopes are used for different purposes.
- They are primarily used for the observation of minute particles which cannot be observed with naked eyes.

11. Hot air oven

- A hot air oven is an electrical device that is used for sterilization of medical equipment or samples using dry heat.

Working Principle

- Hot air oven is a type of dry heat sterilization which is performed on dry materials and on substances that do not melt or catch fire under high temperature.
- There are two types of hot air oven based on the working principle
    - Forced air hot air oven: In this type of hot air oven, the heated air inside the oven is distributed throughout the oven with a fan. This prevents the rising of hot air towards the top while keeping the cold air at the bottom. This allows for the adequate heating of materials inside the oven.
    - Static air hot air oven: In this type of oven, the heat is produced by coils present at the bottom of the oven with no fan. The hot air rises and doesn't allow the effective sterilization of the materials.
- The equipment inside the oven acquire heat and pass the heat towards the center, one layer at a time which allows for effective dry heat sterilization.

Uses

- Hot air oven can be used to sterilize materials like glassware, metal equipment, powders, etc.
- It allows for the destruction of microorganisms as well as bacterial spores.

12. Incubator

- An incubator is a device that is used in the laboratories for the growth and maintenance of microorganisms and cultures.
- Incubator provides an optimal temperature, pressure, moisture, among other things required for the growth of microorganisms.

Working Principle

- The incubator is based on the principle of maintaining a proper atmosphere for the growth of microorganisms.
- Incubators have a heating system that allows for the temperature within the incubator to be adjusted according to the type of organism cultivated inside.
- Similarly, they are provided with adjustments for maintaining the concentration of CO_2 to balance the pH and humidity required for the growth of the organisms.
- Variation of the incubator like a shaking incubator is also available, which allows for the continuous movement of the culture required for cell aeration and solubility studies.

Uses

- Incubators have a wide range of applications including cell culture, pharmaceutical studies, hematological studies, and biochemical studies.
- Incubators can also be used in the steam cell research area.

13. Deep Freezer

Working Principle

- Deep freezers are based on the principle that under extremely low temperatures, there is minimum microbial growth which allows for the protection and preservation of different substances.
- Based on this principle, we can even preserve cultures over a long period of time without any change in the concentration of the microorganisms.

Uses

A deep freeze can be used for the preservation of different things used in the laboratories for a very long period of time. Deep freezers are used in laboratories to store and preserve medical equipment, food items, blood samples, medicines, and injections, etc. for a more extended period of time.

14. Hot plate

- A hot plate is a stand-alone appliance used in microbiology laboratories as a tabletop heating system.

Working Principle

- Unlike the traditional ways of producing heat through the fire, a hot plate produces heat by the flow of electricity.
- On a hot plate, electricity runs through the coils which have a high level of electrical resistance. The resistance in the coils converts the electrical energy into heat energy which causes the coils to release heat.

Uses

- In a laboratory, hot plates are used to heat glassware and their components.
- They are used over water baths as in water baths might be hazardous in case of any spills or overheat.

15. Magnetic Stirrer

- Magnetic Stirrer is a device commonly used in microbiology laboratories for the purpose of mixing liquids.

Working Principle

- This device consists of a rotating magnetic or an electromagnet creating a rotating magnetic field that allows the stir bar (a piece of heavy metal) to move around in the vessel.
- It is coupled with a heating system to heat the liquid while it mixed.

Uses

- It is usually used for mixing various liquid components in a mixture in a chemical or microbiology laboratory.
- This device is used in place of other stirrers as it is noise-free and because the size of the stir bar is so tiny, there is less chance of contamination.

16. Water Distiller

- A water distiller is a device that purifies water by the process of distillation.
- This instrument is commonly used in medical laboratories, microbiology laboratories, organic chemistry laboratories and medical industries.

Working Principle

- A water distiller is based on the principle of distillation.
- According to this process, water is first brought to a boil and then condensed into liquid form to obtain pure distilled water.

Uses

- It is used to obtain distilled water required for many lab tests as well as for the preparation of chemicals and culture media.

17. Bunsen burner

- Bunsen burner is a standard tool used in laboratories, named after Robert Bunsen.
- It is a gas-fueled single open flame.

Working Principle

- This burner is made with a metal tube on a flat base with a gas inlet at the bottom of the tube, which may have an adjustable valve. On the sides of the tube are openings which can be adjusted with a collar to control the amount of air that can enter.
- Once the burner is connected to a gas source, the gas is forced by the gas pressure so that the gas reaches the top where the flame is ignited with a match or a lighter.

Uses

- It is commonly used for processes like sterilization, combustion, and heating. In medical or microbiology laboratories, it is commonly used for micro-loop sterilization.

Conductivity Meter / Benchtop Conductivity Meters

Conductivity meters measure the electrical conductivity of aqueous solutions. Benchtop conductivity meters are typically used in Hydroponics and aquaculture settings, but can be found in almost any laboratory environment. A conductivity meter can obtain not only electrical conductivity measurements, but total dissolved solid (TDS), pH, percent NaCl, resistance, and temperature measurements as well. A benchtop conductivity meter can have a conductivity range of 0.001 uS/cm to 1000 mS/cm or greater, and offer linear, non-linear, automatic (ATC) temperature compensation, or manual temperature compensation (MTC). Particular features include high reproducibility, calibration reminders, multiple calibration points, and generous data storage.

Dissolved Oxygen Analyzer / Dissolved Oxygen Monitor

Dissolved oxygen refers to the amount of oxygen present in water and is a common indicator of water quality as levels too high or too low can harm aquatic life. Dissolved oxygen meters, also called dissolved oxygen analyzers, are the most common and effective means of measuring oxygen levels in water. A standard model consists of a probe and a monitor for reading off and recording oxygen levels. To make measurements more precise, many models make automatic adjustments to account for fluctuations in factors such as pressure and temperature that might otherwise affect oxygen readings. In some cases, the probes serve dual purposes or can be switched out to monitor other variables such as pH or CO_2 levels.

The two main types of oxygen meters are optical (also called luminescent meters) and electrochemical meters. Electrochemical meters take faster readings but need to be stirred in a solution to calibrate before use. Optical meters last longer and do not need to be calibrated before each use, but their readings take longer and they require more power.

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Total Suspended Solids (TSS)

Procedure
50mL of a well-mixed sample was filtered through a weighed standard glass-fiber filter paper. The residue retained on the filter was then dried in an oven at 103 to 105°C for 1 hour. It was then cooled in a dessicator and weighed. The increase in weight of the filter represents the total suspended solids.

Calculation
The TSS was computed for using the formula below:

$$mg\ total\ suspended \frac{solids}{L} = \frac{(A - B) \times 1000}{sample\ volume, mL}$$

A = weight of filter + dried residue, mg, and
B = weight of filter, mg.

Total Solids (TS)

Procedure
Ignite the crucible, partially cool, place in the desicator to cool to room temperature, and weigh, measure 100mL of a well-mixed sample into the crucible, evaporate to dryness on a steam bath and further dry in the oven at 105°C for 1-2 hours. It was then cooled in a desicator and weighed, for best result dry in the oven again, cool in desicator and re-weigh. The difference in weight is express in mg/l.

Calculation
The TS was computed for using the formula below:

$$mg\ total\ \frac{solids}{L} = \frac{(A - B) \times 1000}{sample\ volume, mL}$$

A = weight of crucible + dried residue, mg, and
B =Initial weight of crucible, mg.

Alkalinity is the quantity of ions in water that will react to neutralize hydrogen ions.

pH is a measure of hydrogen ion concentration, a measure of the acidity or alkalinity of a solution. The **pH** scale usually ranges from 0 to 14. Aqueous solutions at 25°C with a **pH** less than 7 are acidic, while those with a **pH** greater than 7 are basic or alkaline.

BOD means Biochemical Oxygen Demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature.

COD means Chemical Oxygen Demand (COD test determines both degradable and non-degradable substances. That is the total measurement of all chemicals in the water that can be oxidized.

PARAMETERS	**UNIT**	**WHO G/LINES**
pH	-	6.5-8.5
TURBIDITY	NTU	0-5
TOTAL DISSOLVED SOLIDS	mg/L	0-1000
COLOUR	TCU	0-15

TOTAL SUSPENDED SOLIDS	mg/L	0.0
TOTAL HARDNESS($CaCO_3$)	mg/L	0-500
CALCIUM HARDNESS($CaCO_3$)	mg/L	-
NITRATE AS NITROGEN	mg/L	0-10
NITRITE AS NITROGEN	mg/L	0-0.1
IRON	mg/L	0-0.3
MANGANESE	mg/L	0.05
FLUORIDE	mg/L	0-1.5
CHLORIDE	mg/L	0-250
SULPHATE	mg/L	0-250
CONDUCTIVITY	µS/cm	0-2000
CALCIUM	mg/L	0-100
MAGNISIUM	mg/L	0-200
NON- FAECAL COLIFORMS	N/100	0
E-COLI	N/100	0
SALMONELLA	N/100	0
BOD	mg/L	50
COD	mg/L	250

SOME PARAMETERS AND GUILDLINES VALUES

Parameter	Unit	Test Remarks	Requirement	Methods
Physical & Chemical *):				
· Colour	Pt. Co scale	3	15	Colorimetric
· Odour	Pt. Co scale	negative	odourless	Organoleptic
· pH	Pt. Co scale	6.50	6.5-8.5	Electrometric
· Taste	Pt. Co scale	normal	tasteless	Organoleptic

· Turbity	FTU	1	5	Turbidity
· Aluminum	mg/l	below 0.20	0.2	AAS
· Copper	mg/l	below 0.03	1.0	AAS
· Iron Total	mg/l	below 0.04	0.3	AAS
· Manganese	mg/l	0.06	0.1	AAS
· Sodium	mg/l	96.93	200	AAS
· Zinc	mg/l	0.047	5	AAS
· Chloride	mg/l	140.41	250	Argentometric
· Flouride	mg/l	0.09	1.5	Colorimetric
· Nitrate	mg/l	below 0.11	10	Colorimetric
· Nitrite	mg/l	0.96	1	Colorimetric
· Sulphate	mg/l	below 0.94	400	Turbidimetric
· Arsenic	mg/l	below 0.001	0.05	AAS
· Barium	mg/l	below 0.10	1	AAS
· Cadmium	mg/l	below 0.005	0.005	AAS
· Cyanide	mg/l	below 0.01	0.1	Colorimetric
· Chrom Hexavalent	mg/l	below 0.006	0.05	Colorimetric
· Lead	mg/l	below 0.01	0.05	AAS
· Mercury	mg/l	below 0.001	0.001	AAS
· Selenium	mg/l	below 0.007	0.01	AAS
· Organic Matter by $KMnO_4$	mg/l	3.06	10	Permanganantometric
· Dissolved Solid	mg/l	431	1000	Gravimetric
· Hydrogen Sulphide as H_2S	mg/l	below 0.01	0.05	Colorimetric
· Total Hardness	mg $CaCO_3$	95.49	500	AAS
Bacteriological:				
· Total Bacteria	per ml	6.9×10^2	1.0×10^2	Pour Plate
· Coliform	per 100 ml	nil	nil	Filtration
· E. Coli	per 100 ml	nil	nil	Filtration
· Salmonella sp	per 100 ml	negative	negative	Filtration