

Separation and Filtration of Pharmaceutical Laboratory Waste Water For Reuse by Using Combination Technique of Electro-Coagulation and Microbial Electrochemical Cell Lysis Process

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ABSTRACT

The Advancement of human living standards in the twenty-first century, the problems of global climate change, rapid population increase, and environmental pollution have grown increasingly critical. Human activities have put a lot of strain on the ecosystem. Water contamination is one of several environmental issues that must be addressed immediately. Therise in water-related disorders provides a realistic estimate of the extent of environmental degradation. Humans can utilize it day by day. Water can be used in a pharmaceutical laboratory or industry for the formulation, chemical synthesis, and cleaning, among other things. The final waste water in numerous pharmaceutical laboratories and industries is treated in a variety of ways to remove effluent and pollutants. That water, on the other hand, can be used for gardening and planting. When compared to other traditional procedures such as biological, physical, chemical, adsorption, and advanced oxidation processes, the combination technique of Electrocoagulation and Microbial Electro Cell lysis has high de-colorization efficiency, is economically attractive, and produces very little sludge. Color, COD, BOD, turbidity, and metal ions are among the pollutants that may be removed from wastewater using the electrocoagulation procedure. We are researching the processes of electrocoagulation and microbial electro cell lysis in order to build a wastewater treatment system that is reusable and produces better outcomes. It is incredibly inexpensive and straightforward, with only a few substances being utilized in the treatment and administration. We are considering the future when creating such a design.

Keywords: Laboratory waste water, Electro-coagulation, Microbial electro cell lysis, Electrodes.

I. INTRODUCTION

Water is an essential component of human production and survival, as well as food security, environmental preservation, and human health. Eutrophication is caused by an increase in industrial pollutants discharged into river. When an ecosystem is destroyed, the oxygen content of water is lowered, and many fish and other species are killed, posing a problem for water resource conservation. Consumers' living standards have risen, resulting in a need for higher-quality and quantity water than in the past. The globe has uncovered new causes of pollution practically every day since the industrial revolution in the late eighteenth century. As a result, pollution of the air and water can occur anywhere. The rise in water-related disorders provides a realistic estimate of the extent of environmental degradation. Water is the second most important requirement for life. As a result, the scientific literature on water quality has become quite comprehensive. Water quality refers to how well water meets the needs of one or more biotic species, as well as any human demand or goal. Parameters like pH and dissolved oxygen are used to determine chemical properties. For drinking and daily use, water quality must be paramount. As a result, water must be of high quality for both human and environmental reasons, as well as for future use. One of the most significant is that it has a number of criteria, such as WHO, US, and others, that can be used to authorize water for human and industry use.⁽¹⁾

Essential of water in pharmaceutical laboratory and industry

Water is one of the most commonly used materials in pharmaceutical laboratories.

It may be present as excipients or employed as a cleansing agent or in the final product's manufacturing.

- Potable water,

- purified water, water for injections, and
- Sterile water is all sorts of waters utilized in the pharmaceutical laboratory and industry.

Water quality parameters

Physical, chemical, and biological are the three types of water quality parameters⁽¹⁰⁾

No.	Types of water quality parameters		
	Physical parameters	Chemical parameters	Biological parameters
1.	Turbidity	PH	Bacteria
2.	Temperature	Acidity	Algae
3.	Color	Alkalinity	Viruses
4.	Taste	Chloride	Protozoa
5.	Total Dissolved Solids	Chlorine residual	-
6.	Electrical conductivity	Sulfate	-
7.	Total Suspended Solids	Nitrogen	-
8.	Odor	Fluoride	-
9.	-	Iron and manganese	-
10.	-	Copper	-
11.	-	Hardness	-
12.	-	Dissolved oxygen	-
13.	-	Biochemical oxygen demand	-
14.	-	Chemical oxygen demand	-
15.	-	Toxic inorganic substances	-

Usage of water in pharmaceutical laboratory and Industry

- The Excipient or used for reconstitution of products

- During synthesis
- During production.
- Cleaning agent for rinsing vessels, equipment.

Characteristics of the Pharmaceutical Laboratory wastewater

Parameter	Concentration (mg/L)
pH	6.5-7.40/6.5-9.5
Total alkalinity	1800-2200
TDS	15500-16500
Suspended solids	9150-950

COD	23700-24600
BOD	11500-12300

Acceptable ranges of water

PARAMETERS	RANGES	WHO	BIS STANDARD	
			MINIMUM	HIGH
pH	6.2-7.6	6.5-8.5	6.5	8.5
EC	164-1990	400-2000	-	-
IDS	101-1334	500-1000	500	2000
Calcium	8-154	100-200	75	200
Magnesium	364-47.365	30-40	35	105
Sodium	5.3-174	20-1777	-	-
Potassium	0.97-80	10-12	-	-
Bicarbonate	42-420	-	200	600
Sulfate	0-109.63	25-250	200	400
Chloride	3.16-262.44	25-600	250	1000
Fluoride	0-0.975	-	1.0	1.5
Alkalinity	38-380	-	200	600
TotalHardness	36-360	-	300	600

Treatment of wastewater

Wastewater treatment is a technique used to remove impurities from waste water and convert it into reuse.

Stages of water treatment

- Collection of water.
- Screening and Straining.
- Chemical Addition.
- Coagulation.
- Sedimentation.
- Filtration.
- Disinfection.
- Storage.

Techniques involved in separation of waste water

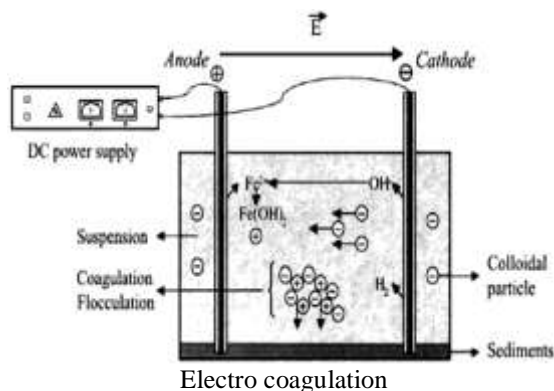
Electro-coagulation

Total suspended solids (TSS), heavy metals, emulsified oils, bacteria, and other pollutants are removed from water using electrocoagulation (EC), a broad-spectrum treatment method. Several authors have employed EC to treat wastewater, and several distinctions

have been discovered when compared to the chemical coagulation technique. According to a review of the literature, EC is an effective treatment method for a variety of wastes. EC is a technique that removes hydrocarbons, greases, suspended solids, and heavy metals from various types of waste water to de-stabilize finely distributed particles. Aluminum or iron are commonly utilized as electrodes, and their cations are produced by the dissolving of sacrificial anodes when a direct current is applied. Electrical current flows between two electrodes in an EC. Electrolytic oxidation of the anode material produces a coagulant in situ. For the treatment of synthetic wastewater, iron (Fe) electrodes were used in this study. $Fe(OH)_n$ with $n = 2$ or 3 is generated at the anode with an iron anode. The equations in Mechanisms depict simplified oxidation and reduction mechanisms at the anode and cathode of the iron electrodes. The formation of iron hydroxides $Fe(OH)_n$ is followed by an electrophoretic concentration of colloids (typically negatively charged) in the region near the anode.

Surface complexation or electrostatic attraction are used to remove particles that interact with iron

hydroxides.^(7,17,18,19,20)



Electro-coagulation process

- 1- Formation of coagulants by electrolytic oxidation of sacrificial electrode.
- 2- Formation of OH⁻ and Hydrogen at the cathode.
- 3- Electrolytic reactions at the electrode surfaces.
- 4- Form flocculation.
- 5- Removal of colloids by sedimentation or flotation.

Microbial electro chemical cell lysis

Microbial Electro cell lysis (MECL) uses cathodically generated hydroxide (i.e., localized high pH) to break fatty acid-glycerol ester linkages in phospholipids to rupture microbial cell membranes.

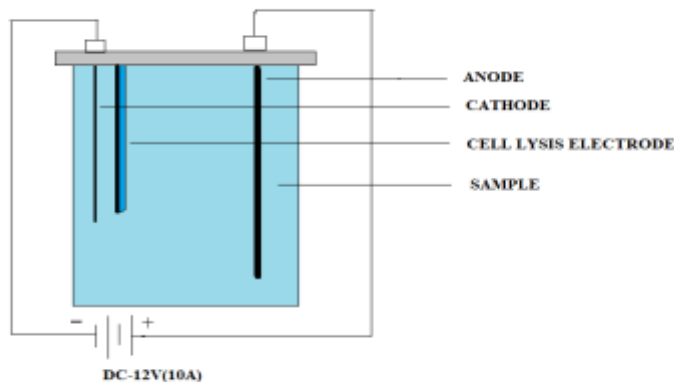
EL requires substantially lower voltages (e.g., 2–5 V) than high-voltage electroporation (e.g., 500 V),

which eliminates joule heating and hence may be easily used under resource limited conditions observed in remote field sampling locations to eradicate bacteria and microorganisms.^(12,13)

Combination process

- This two techniques are involved in one combine process. When the electric current is passed in the sample, the pH get increased nearby cathode.
- When pH gets increased, the bacterial cell wall get destroyed by the process of electro-chemical cell lysis process.
- The cell is trapped by cell lysis electrode and appears as **BLUE** in color such as bacteria.
- The remaining contaminants get some floated and sedimented in water.

VOLTAGE APPLIED α SEPARATION TIME



New design of EC and ECL

Combination techniques of electrocoagulation and Microbial electrochemical cell lysis

The color of the sample changes during the process of two combination techniques, and these colour changes indicate the presence of Metal ions, Chemicals, Microorganisms. However, modern strategies have entailed studying microorganism cell lysis and then trapping them in different electrodes. When the trapping electrode is present in between the cathode and the anode, the pH on the cathode side increases, and the cell dies as a result of the microbe moving in between the cathode and the anode. Conductivity causes entrapment to happen.

II. MATERIALS AND METHODS

2.1. Materials

Wastewater samples should be collected from the Pharmaceutical industry and Pharmaceutical laboratory.

2.2. Methods

The electrocoagulation method is a widely used water separation technology that can employ a variety of chemicals. The new design does not require any chemicals, and Ethanol may be used as a water disinfectant to kill germs and other pathogens. To improve water treatment results, electro-coagulation and microbial electro cell lysis are used.

III. METHODOLOGY

Step-1

The pharmaceutical laboratory should be contacted for a water sample. The samples must be reported in a variety of ways because there are more than five different sorts of samples. After the samples have been collected, they are sealed and labeled as sample 1,2,3,4,5. They are immediately identifiable. When the sample is poured into an electrocoagulation cell and the current is passed as a DC current of roughly 12V(10A), the sample is coagulated. When current passes through the iron electrodes, sludge is generated.

Step-2

When the sludge has settled to the bottom of the cell, mix for 5 minutes with a magnetic stirrer. Repeat the method for the next three phases after filtering using whatman filter paper.

Step-3

After collecting the filtrate, add powder charcoal because powder charcoal may be used to remove chlorine, odor, and taste.

Step-4

Due to the gas absorption of water, add granular charcoal.

Step-5

During the process, the pH of the above water changes. As a result, citric acid is added to lower the pH. The pH of the water should be between 6.5 to 8.5, according to WHO, and disinfectants, such as ethanol, should be added to destroy microorganisms like bacteria.

Step-6

Finally, add both the powder and granular charcoal to the water and stir for 10 minutes with a magnetic stirrer after allowing to settle for 24 hours.

Step-7

After filtering the water using filter paper, the distillation process begins.

Step-8

Water quality control is required to ensure that the acceptable level of contaminants in the water meets WHO recommendations. Let's have a look at the many criteria that will be checked.

IV. RESULTS AND DISCUSSION

4.1. Physical Parameters

4.1.1. Turbidity

Turbidity is the cloudiness of a liquid generated by particles that are normally unseen by the naked eye. The Chinese turbidity chart method will be used to determine this. The turbidity of water is very clear and has a value of less than 5 NTU.

4.1.2. Temperature

The major people prefer the water that is between 10 to 25°C. The provided water sample has a temperature of 16°C.

4.1.3. Color

The color of the water is determined by comparing it to standard color solutions or colored glass discs.

A water sample can appear as **true color**.

4.1.4. Taste and odor

Foreign matter, such as organic items, inorganic compounds, or dissolved gases, can alter the taste and odor of water. The water sample provided has **no taste or odor**.

4.1.5. Total dissolved solids

Solids can be found in water in two states: solution and suspension. These two forms of solids can be distinguished by passing a water sample through a glass fiber filter. The dissolved solids pass through the filter with the water, while the suspended solids are kept on the top of the filter. The particulates will remain as a residue if the

filtered portion of the water sample is placed in a tiny dish and subsequently evaporated.

Procedure

- In a beaker, collect 50 mL of water.
- To set the crucible in the weighing machine, use a petri dish and filter paper to record the empty weights of each.
- Place the filter paper in the membrane filter and click the beaker to slowly pour 50ml of sample from the top of the filter.
- To remove the filter paper from the filter, click on the temperature set button and set the oven temperature to 103°C for the night.
- The material that passes through the filter paper is collected in a crucible.
- To keep it in the oven, take a sample and adjust it.
- Remove the petri dish and crucible from the hot air oven and place them in the desiccator to cool.
- Make a note of the final weight of the ash, minus the filter paper, as well as the final weight of the crucible.

Observation

It a general method and time-consuming process. However, the simplest method is to place a TDS Meter in the water and observe the value. The water sample given a **TDS level is 248ppm**. So, it is the BIS/WHO standard range of water

4.1.6. Electrical conductivity (EC)

Electrical conductivity (EC) is a measurement of a solution's capacity to carry or conduct an electrical current. The simplest method is to place an Electrical conductivity (EC) Meter in the water and observe the value.

The given Water sample has an electrical conductivity of **1646.66 µS/cm**.

4.2. Chemical Parameters

4.2.2. pH

A pH meter can be used to determine the pH. The provided water has a **pH of 7.3**.

4.2.3. Acidity

Acidity is a measurement of how many acids are present in a solution.

In the supplied water sample, there is **no acidity**.

4.2.4. Alkalinity

The acid-neutralizing ability of all titratable bases is used to calculate the alkalinity of water.

The alkalinity of water must be measured to determine the amount of lime and soda required for water softening.

Testing the water sample

- Rinse the burette with 0.02N sulphuric acid and then throw away the solution.
- Fill the burette halfway with 0.02N sulphuric acid and set the dial to zero.
- Place the burette in the stand and secure it.
- Measure 100 ml a sample with a measuring cylinder and pour it into a 250 ml conical flask.
- Toss a few drops of phenolphthalein indicator into the conical flask's contents. The solution's color will change to pink. The alkalinity of hydroxyl ions in the water sample causes this color change.
- Titrate it with 0.02N sulphuric acid until it loses its pink. This means that all of the hydroxyl ions in the water sample have been eliminated. Make a note of the titer value (V1). The titration value is 0.5mL.
- The phenolphthalein alkalinity is calculated using this value.

Sl.No.	Volume of Sample (ml)	Burette Reading (ml)		Volume of sulphuric acid (ml)
		Initial	Final	
1.	100	0	0.6	0.6
2.	100	0	0.5	0.5
3.	100	0	0.5	0.5

$$\text{Phenolphthalein Alkalinity} = \frac{\text{volume of H}_2\text{SO}_4 (v1) * \text{Normality} * 50 * 1000}{\text{Volume of sample taken}}$$

The water sample given has an alkalinity is **5mg/L**. So, it is the BIS/WHO standard range of water.

4.2.5.Hardness

Temporary hardness is due to carbonates and bicarbonates. The hardness of water is determined by the EDTA titration method.

The water sample given has an alkalinity for **55mg/L(approximately)**. So, it is the BIS/WHO standard range of water.

4.2.6.Chloride

Chlorides are not harmful to people. The **total amount of chloride** in a given water sample is **176 mg/L(approximately)**.

4.2.7.Residual chlorine

Residual chlorine is a disinfectant that is added to water and wastewater since it does not occur naturally in water. It is determined by using UV spectroscopy by using standard chlorine solution. The total amount of **residual chlorine** present in water is **0.3 mg/L**.

4.2.8.Fluoride

The highest authorized content of fluoride for water is 1.4 mg/L; in colder areas, up to 2.4 mg/L is allowed. It is determined by ion- selective electrode. The **concentration of fluoride** in a given water sample is **2.6 mg/L**.

4.2.9. Nitrogen

There are four forms of nitrogen in wastewater: organic nitrogen, ammonia nitrogen, nitrate nitrogen, and nitrite nitrogen. It is determined by using UV spectroscopy by using standard chlorine solution.

The **total amount of nitrogen** present in given a water is **0.20 ppm(approximately)**

4.2.10.Copper and zinc

It is non-toxic for humans.It is determined by using Colorimetry. The concentration of copper present in a given water sample is **0.5mg/L**.

4.2.11.Dissolved oxygen

The three major methods for determining dissolved oxygen concentrations.

- Colorimetric method
- Winkler titration method
- Electrometric method
- DO meter.

DO meter

For 30 seconds, the DO sensor is immersed in the water sample and standard.

The water sample given has a **DO level** is **7.2 mg/L**. So, it is the BIS/WHO standard range of water.

4.2.12.Iron

The method of UV SPECTROSCOPY is used to determine the iron concentration. It provides a precise value.

Procedure

From a standard iron solution, different concentrations of iron solution are prepared, and absorbance and transmittance are measured including water sample and to draw a calibration curve (figure 1 and figure 2)

Absorbance

Concentration	Absorbance
0.5	0.0132
1.0	0.0135
1.5	0.139
2.0	0.017
2.5	0.0144
Water sample	0.0499

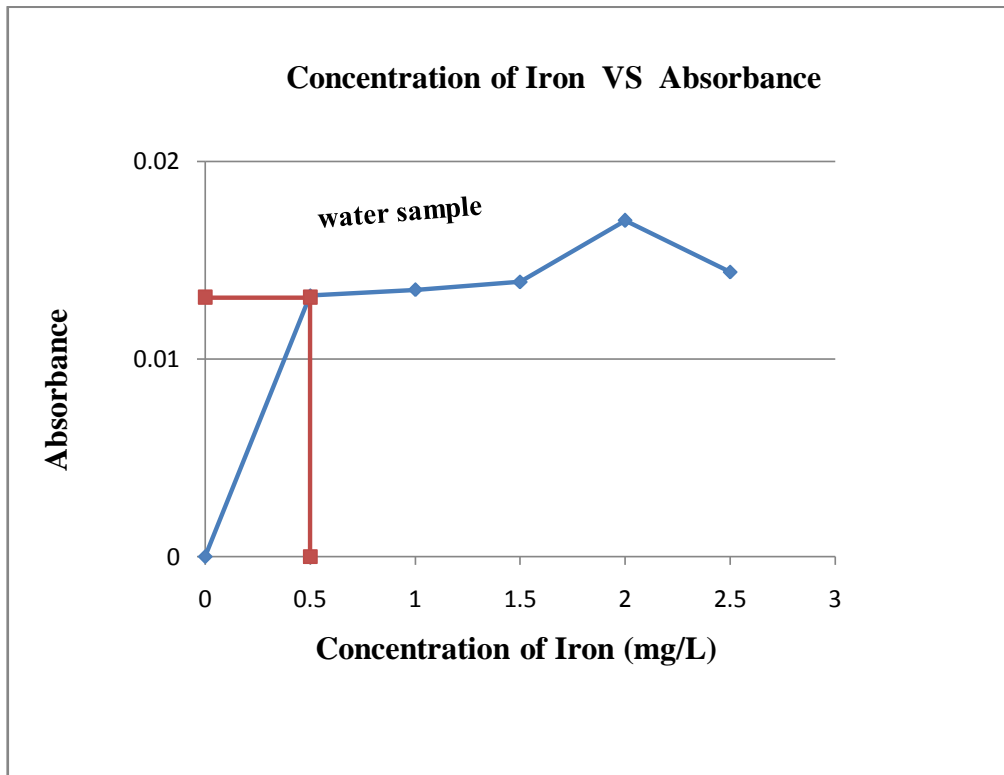


Figure no.1

Transmittance

Concentration	Transmittance
0.5	95.7
1.0	95.6
1.5	95.22
2.0	95.17
2.5	95.10
Water sample	94.62

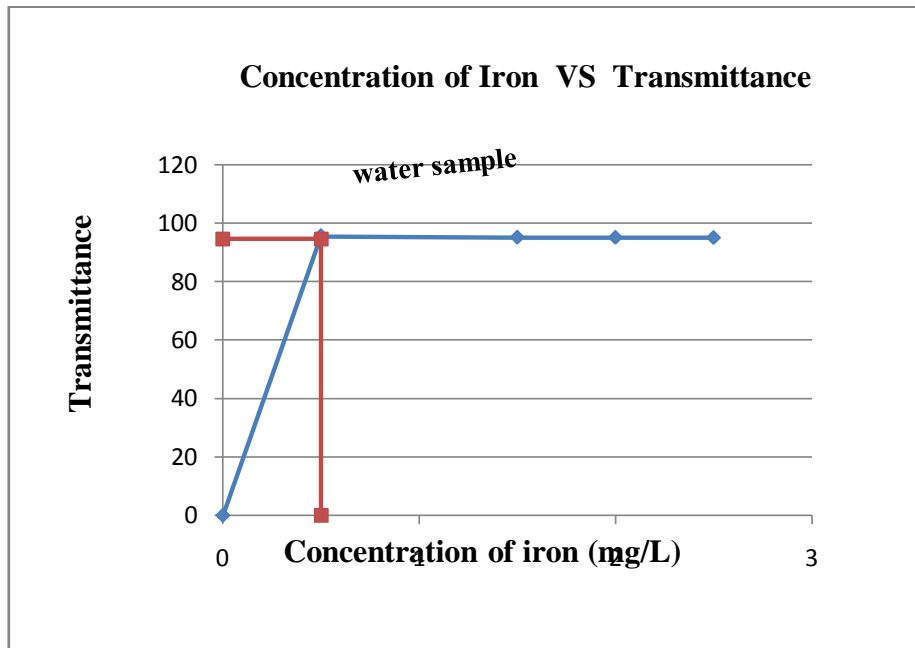


Figure no.2

The water sample given has an **Iron concentration** is **0.5 mg/L**. So, it is the BIS/WHO standard range of water.

4.2.13.Sulfate

The method of UV-VISIBLE SPECTROSCOPY is used to determine the sulfate concentration. It provides a precise value (figure 3 and figure 4)

Procedure

From a standard sulfate solution, different concentrations of sulfate solution are prepared, and absorbance and transmittance are measured including water sample and to draw a calibration curve.

Absorbance

Concentration	Absorbance
5	0.0523
10	0.0710
15	0.2781
20	0.2744
25	0.2691
Water sample	0.0499

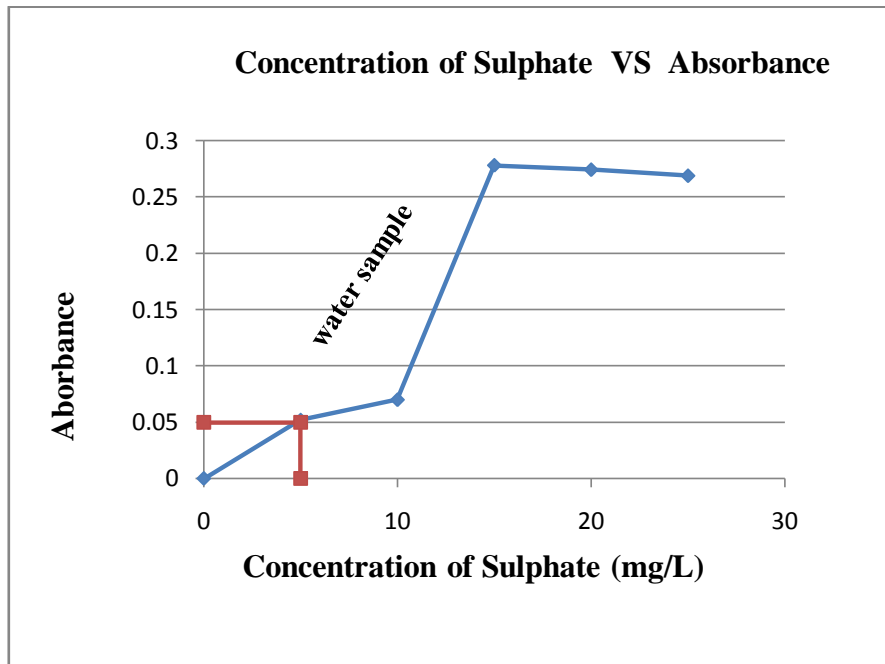


Figure no.3

Transmittance

Concentration	Transmittance
5	77.99
10	41.86
15	41.52
20	40.86
25	37.26
Water sample	77.09

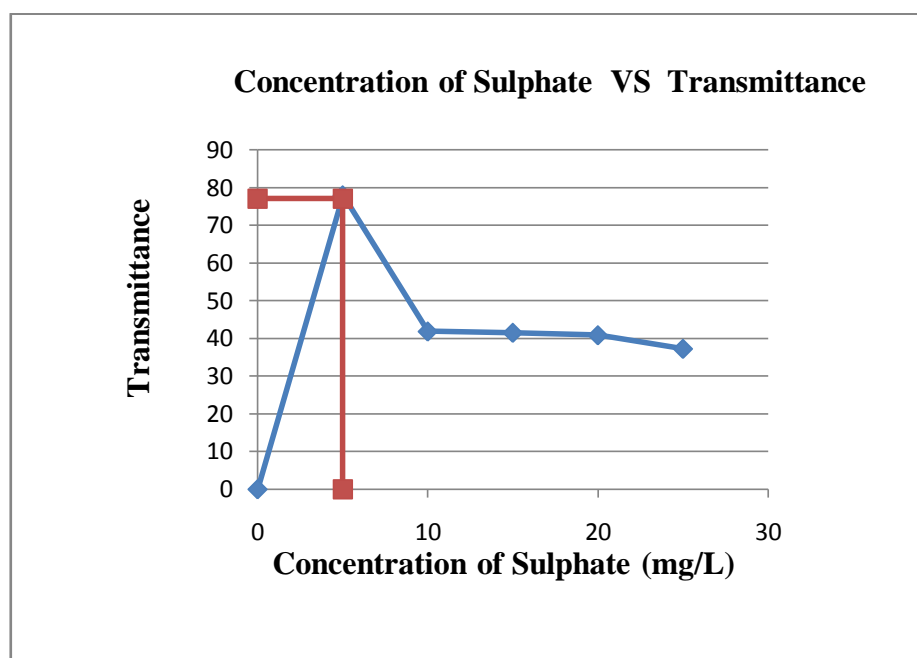


Figure no.4

The water sample given has a **sulfate concentration** is **5mg/L**. So, it is the BIS/WHO standard range of water.

4.2.14. Biological Oxygen Demand

Biochemical oxygen demand (BOD) Bacteria and other microbes feed on organic matter. The organics are broken down into simpler chemicals like CO₂ and H₂O, and the energy released is used by the microorganisms to grow and reproduce. The oxygen utilized in this process in water is the DO in the water.

BOD meter

For 30 seconds, the BOD sensor is immersed in the water sample and standard.

The water sample given has a **BOD level** is **4ppm**. So, it is the BIS/WHO standard range of water.

4.2.15. Chemical Oxygen Demand

The chemical oxygen demand (COD) is a metric for all organics, including biodegradable and non-biodegradable materials.

COD meter

For 30 seconds, the COD sensor is immersed in the water sample and standard.

The water sample given has a **COD level** is **27mg/L**. So, it is the BIS/WHO standard range of water

4.2.16. Toxic Inorganic Substance

Water can include a wide range of inorganic hazardous chemicals in extremely minute or negligible concentrations. They can be harmful to people's health even in trace doses. Some toxic

compounds come from natural sources, but many more come from industrial activity and/or inappropriate hazardous waste management.

The water sample given has **No Toxic Inorganic Substance**. So, it is the BIS/WHO standard range of water.

4.2.17. Biological Parameters

The water is treated in an electro-coagulation cell, which removes more than 75% of microorganisms. After moving on to the next step of the water treatment process, which is the distillation process, which should eliminate all microorganisms.

V. ADVANCES TECHNIQUE ON WATER QUALITY DETECTION FOR LABORATORY WASTE WATER

Chemical, biological, and physical approaches are commonly used to determine water quality factors. Titration analysis and electrochemical analysis are the two most common chemical procedures. The apparatus is enormous and expensive, and it requires a significant number of chemicals, resulting in secondary contamination; also, the results are not real-time. The most popular water quality monitoring system entails manually collecting water samples in a laboratory for examination, making it impossible to meet the needs of online real-time monitoring. Hence, UV spectroscopy is used for online monitoring of

Waste Water. Enrichment analysis and biosensor technology are the most used biological methods; however, the detection accuracy and sensitivity are much lower than with other methods. Hyperspectral remote sensing and molecular spectroscopy are two of the most used physical approaches.

VI. CONCLUSION

The conclusion of the study where laboratory wastewater can be converted to human use. Our planet's water supply can be depleted on a daily. This will continue, with no water in the world once a day. In each pharmaceutical laboratory and industry, roughly 1000 kilolitres of water are used. The daily use of new water was greatly decreased due to the reuse of wastewater. The innovative design of electrocoagulation can lower the amount of electricity used while providing superior outcomes. We're thinking about the future when it comes to creating a new design. As a result, new freshwater produces better results.

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