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Separation and Purification of Pharmaceutical Industrial Waste Water for Reuse by Techniques of Electro-Coagulation and Microbial Electrochemical Cell Lysis Process

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ABSTRACT

The Advancement of human living standards within the twenty-first century, the issues of worldwide global climate change, rapid population increase, and environmental pollution have grown increasingly critical. Human activities have put plenty of strain on the ecosystem. Water contamination is one amongst several environmental issues that has to be addressed immediately. The rise in water-related disorders provides a sensible estimate of the extent of environmental degradation. Humans can utilize it day by day. Water will be employed in a pharmaceutical laboratory or industry for the formulation, chemical synthesis, and cleaning, among other things. The ultimate wastewater in numerous pharmaceutical laboratories and industries is treated in a very sort of ways to get rid of effluent and pollutants. That water, on the opposite hand, are often used for gardening and planting. Compared to other traditional procedures like biological, physical, chemical, adsorption, and advanced oxidation processes, the mixture technique of Electro coagulation and Microbial Electro Cell lysis has high de-colorization efficiency, is economically attractive, and produces little sludge. Color, COD, BOD, turbidity, and metal ions are among the pollutants that will be far away from wastewater using the electro coagulation procedure. We are researching the processes of electro coagulation and microbial electro cell lysis in order to make a wastewater treatment system that is reusable and produces better outcomes. It is incredibly inexpensive and easy, with only some substances being utilized within the treatment and administration. We are considering the longer term when creating such a design.

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

1. INTRODUCTION

Water is an important component of human production and survival, additionally as food security, environmental preservation, and human health.[1-2] Eutrophication is caused by a rise in industrial pollutants discharged into river. When an ecosystem is destroyed, the oxygen content of water is lowered, and lots of fish and other species are killed, posing an issue for water resource conservation. Consumers' living standards have risen, leading to a requirement for higher-quality and quantity water than within the past. the world has uncovered new causes of pollution practically a day since the commercial revolution within the late eighteenth century. As a result, pollution of the air and water can occur anywhere. the increase in water-related disorders provides a practical estimate of the extent of environmental degradation. Water is that the second most significant requirement for all times. As a result, the scientific literature on water quality has become quite comprehensive. Water quality refers to how water meets the requirements of 1 or more biotic species, additionally as any human demand or goal.[3-5]

Parameters like pH and dissolved oxygen are wont to determine chemical properties. For drinking and daily use, water quality must be paramount. As a result, water must be of top quality for both human and environmental reasons, yet as for future use, one in all the foremost significant is that its variety of criteria, like WHO, US, and others, which will be accustomed authorize water for human and industry use.[6-9]

1.1 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.

1.2 Water Quality Parameters

Physical, chemical, and biological are the three types of water quality parameters [10]

Table No 01

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	-

1.3 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.

1.4 Characteristics of the Pharmaceutical Laboratory Wastewater

Table No 02

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

1.5 Acceptable Ranges of Water

Table No 03

PARAMETERS	RANGES	WHO	BISSTANDARD	
			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	3.64-47.365	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
Total hardness	36–360	-	300	600

1.6 Treatment of Wastewater

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

1.6.1 Stages of water treatment

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

1.7 Techniques Involved in Separation of Waste Water [11]

1.7.1 Electro-coagulation

Total suspended solids (TSS), heavy metals, emulsified oils, bacteria, and other pollutants are far from water using electrocoagulation (EC), a broad-spectrum treatment method. Several authors have employed EC to treat wastewater, and several other distinctions are discovered compared to the chemical coagulation technique. in keeping with a review of the literature, EC is a good treatment method for a spread of wastes. EC could be a technique that removes hydrocarbons, greases, suspended solids, and heavy metals from various kinds 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 right away current is applied. Electrical current flows between two electrodes in an EC. Electrolytic oxidation of the anode material produces a coagulant in place. For the treatment of synthetic wastewater, iron (Fe) electrodes were utilized in this study. Fe(OH) n with n = 2 or 3 is generated at the anode with an iron anode.

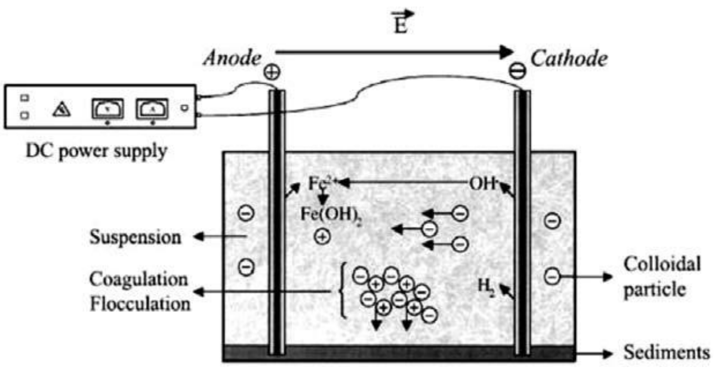

Figure no. 1 - Electro coagulation

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) is followed by an electrophoretic concentration of colloids (typically negatively charged) within the region near the anode. Surface complexation or electrostatic attraction are wont to remove particles that interact with iron hydroxides.

1.8.1.1 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.

1.7.2 Microbial electro chemical cell lysis

Microbial Electro cell lysis (MECL) uses cathodically generated hydroxide (i.e., localized high pH) to interrupt 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 is also easily used under resource limited conditions observed in remote field sampling locations to eradicate bacteria and microorganisms

1.7.3 Combination process

This two techniques are involved in one combine process.When the electrical current is passed within the sample, the pH get increased nearby cathode.

• When pH gets increased, the bacterial plasma membrane get destroyed by the method of electro-chemical cell lysis process.
• The cell is trapped by cell lysis electrode and appears as BLUE in color like bacteria.
• The remaining contaminants get some floated and sedimented in water.

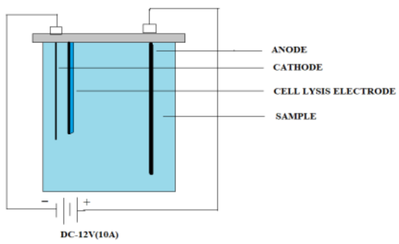

Figure no. 2 - New design of EC and ECL

1.8 Combination Techniques of Electrocoagulation and Microbial Electrochemical Cell Lysis

The color of the sample changes during the method 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 then trapping them in several electrodes. When the trapping electrode is present in between the cathode and therefore the anode, the pH on the cathode side increases, and therefore the cell dies as a results of the microbe occupancy between the cathode and also the anode. Conductivity causes entrapment to happen.

2. MATERIALS AND METHODS

2.1 Materials

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

2.2 Methods

The electrocoagulation method could be a widely used water separation technology which will employ a spread of chemicals. The new design doesn't require any chemicals, and Ethanol is also 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.

2.3 Methodology

2.3.1 Step-1

The pharmaceutical laboratory should be contacted for a water sample. The samples must be reported during a type of ways because there are quite five different types of samples. After the samples are collected, they're sealed and labeled as sample 1,2,3,4,5. they're immediately identifiable. When the sample is poured into an electrocoagulation cell and also 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.

2.3.2 Step-2

When the sludge has settled to the underside of the cell, mix for five minutes with a magnetic stirrer. Repeat the tactic for the following three phases after filtering using whatman paper.

2.3.3 Step-3

After collecting the filtrate, add powder charcoal because powder charcoal is also accustomed remove chlorine, odor, and taste.

2.3.4 Step-4

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

2.3.5 Step-5

During the method, the pH of the above water changes. As a result, acid is added to lower the pH. The pH of the water should be between 6.5 to 8.5, in keeping with WHO, and disinfectants, like ethanol, should be added to destroy microorganisms like bacteria.

2.3.6 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 settlefor 24 hours.

2.3.7 Step-7

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

2.3.8 Step-8

Water internal control is required to confirm that the suitable level of contaminants within the water meets WHO recommendations.

3. RESULTS AND DISCUSSION

3.1 Physical Parameters

3.1.1 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.**

3.1.2 Temperature

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

3.1.3 Color

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

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

3.1.4 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.**

3.1.5.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.

3.1.6 Observation

It ageneral 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 **245ppm.** So, it is the BIS/WHO standard range of water

3.1.7. 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 final Water sample has an electrical conductivity of **1636.66 µS/cm.**

3.2 Chemical Parameters

3.2.1 pH

A pH meter can be used to determine the pH. The provided water has a **pH of** 7**.3.**

3.2.2 Acidity

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

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

3.2.3 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.

3.2.3.1 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 titter value (V1). The titration value is 0.5mL.
- The phenolphthalein alkalinity is calculated using this value

Table No 4

.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

$$\text{Phenolphthalein Alkalinity} = \frac{\text{(olume of } H_2SO_4\text{(v1)xNormalityx50x1000)}}{\text{Volume of sample taken}}$$

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

3.2.4 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**.**

3.2.5 Chloride

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

3.2.6. 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.**

3.2.7.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 **2.7 mg/L.**

3.2.8 Nitrogen

There are four forms of nitrogen in wastewater: organic nitrogen, ammonia nitrogen, nitrate nitrogen, and nitrate 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)**

3.2.9 Copper and zinc

It is non-toxic for humans. It is determined by using Colorimetry. The concentration of copper present in a given final water sample is **0.6mg/L.**

3.2.10 Dissolved oxygen

The three major methods for determining dissolved oxygen concentrations.

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

3.2.10.1 DO meter

For 30 seconds, the DO sensor is immersed in the water sample and standard.The final water sample given has a **DO level** is **6.2 mg/L.** So, it is the BIS/WHO standard range of water**.**

3.2.11 Iron

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

3.2.11.1 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

Table No 05

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

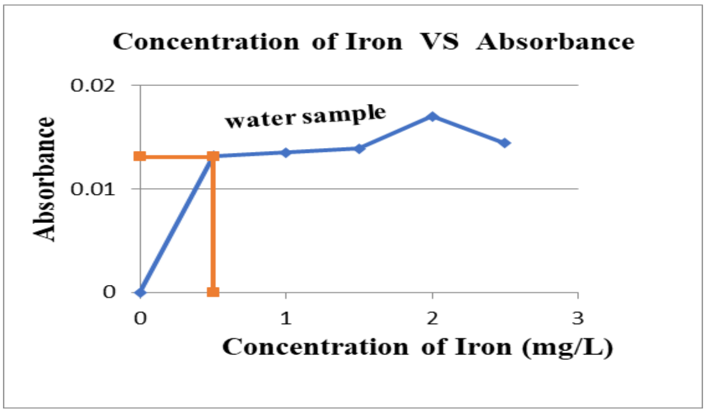

Figure no.3 - Concentration of Iron (mg/L)

3.2.12. Sulfate

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

3..2.12.1 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.

Table No 06

Concentration	Transmittance
0.5	95.7
1.0	95.6
1.5	95.3
2.0	95.2
2.5	94.9
Water sample	94.62

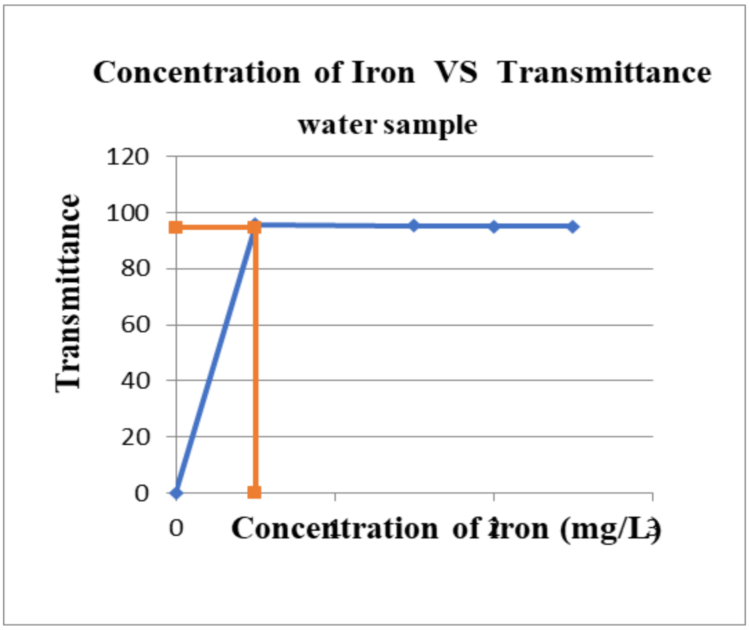

Figure no.4 - Concentration of Iron (mg/L)

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

3.2.13. Biological Oxygen Demand

Biochemical oxygen demand (BOD) Bacteriaand other microbes feed on organic matter. The organics are broken down into simpler chemicals like CO_2 and H_2O, 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.

Absorbance

Table No 07

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

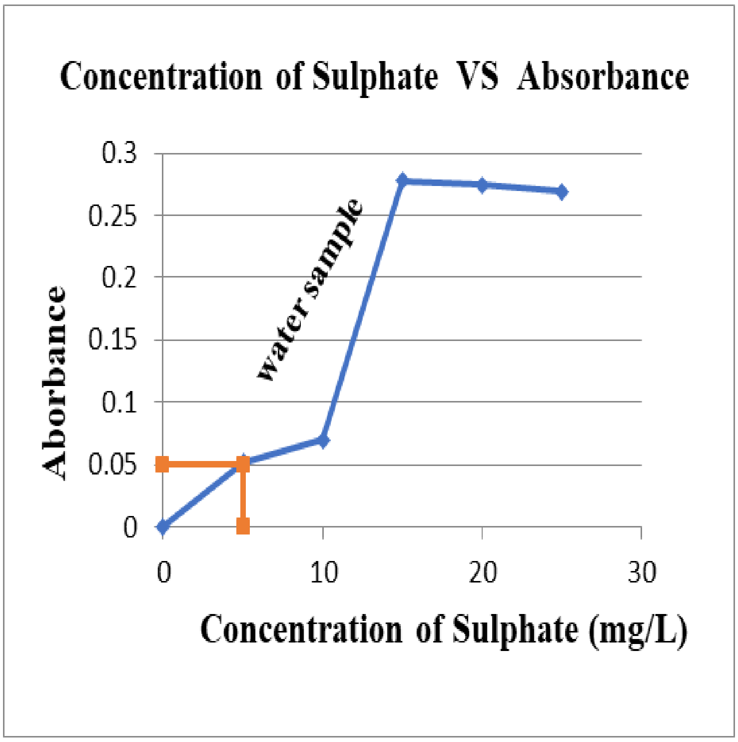

Figure no.4 - Concentration of sulphate (mg/L)

Transmittance

Table No 08

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

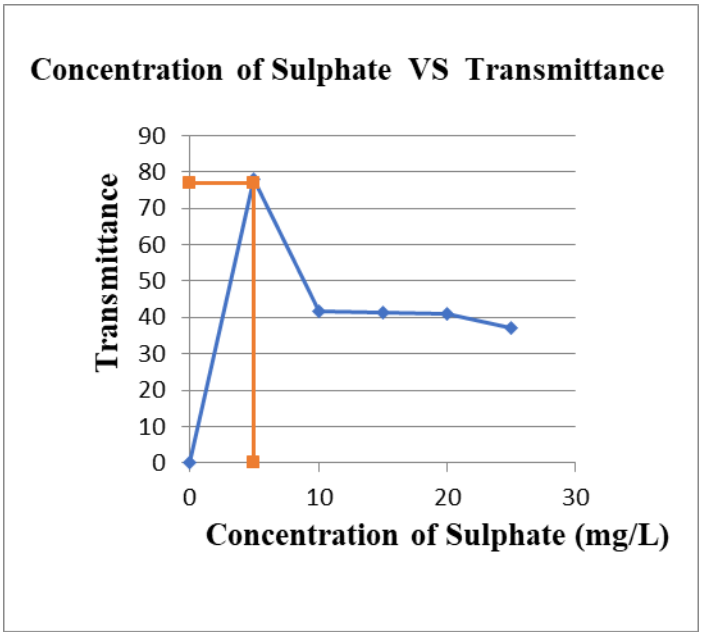

Figure no.5 - Concentration of sulphate (mg/L)

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

3.2.13.1 BOD meter

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

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

3.2.14 Chemical Oxygen Demand

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

3.2.14.1 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

3.2.15 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.

3.2.16 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 watertreatment process, which is the distillation process, which should eliminate all microorganisms.

3.3 Advances Technique on Water Quality Detection for Laboratory Waste Water

Chemical, biological, and physical approaches are commonly accustomed determine water quality factors. Titration analysis and electrochemical analysis are the 2 most typical chemical procedures. The apparatus is gigantic and expensive, and it requires a big number of chemicals, leading to secondary contamination; also, the results don't seem to be real-time. the foremost popular water quality monitoring system entails manually collecting water samples in an exceedingly laboratory for examination, making it impossible to fulfill the wants of online real-time monitoring. Hence, UV spectroscopy is employed for online monitoring of Waste Water. Enrichment analysis and biosensor technology are the foremost used biological methods; however, the detection accuracy and sensitivity are much not up to with other methods. Hyperspectral remote sensing and molecular spectroscopy are two of the foremost used physical approaches.

4. CONCLUSION

The conclusion of the studywhere laboratory wastewater is converted to human use. Our planet's water system will be depleted on a daily. this can continue, with no water within the world once on a daily basis. In each pharmaceutical laboratory and industry, roughly 1000 kilolitres of water are used. The daily use of recent water was greatly decreased thanks to the reuse of wastewater. The innovative design of electrocoagulation can lower the number of electricity used while providing superior outcomes. We're wondering the long run when it involves creating a replacement design. As a result, new freshwater produces better results.

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