

# **Probing of corrosion behaviour for different types of Water based drilling fluid samples on metallic plates and their preventive measures**

University Project – II Report submitted to the Presidency University, Bengaluru in partial fulfillment of the requirements for award of Degree of

**BACHELOR OF TECHNOLOGY**

in

**PETROLEUM ENGINEERING**

By

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**June, 2022**

# **PRESIDENCY UNIVERSITY**

**Bengaluru**

## **Department of Petroleum Engineering**



### **Certificate**

This is to certify that the University Project – II work entitled “Probing of corrosion behaviour for different types of water based drilling fluids on metallic plates and preventive measures” was carried out by Sai Kiran. Pusapati (ID No. 20181PET0069) who is a bonafide student of VIII Semester B.Tech. Petroleum Engineering in Presidency University. This is in partial fulfillment of the course work in place of Professional Practice – II of Bachelor of Engineering in Presidency University, Bengaluru, during the year 2021 - 2022.

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## **DECLARATION**

We do hereby declare that the Project Report entitled “Probing of corrosion behavior for different types of water based drilling fluid samples on metallic plate and their preventive measures” is a record of an original work done by us under the guidance of Mr. Bhairab Jyoti Gogoi, Assistant Professor in the Department of Petroleum Engineering, Presidency University, Bengaluru. This report is submitted by us in partial fulfillment of the requirements for the award of degree of Bachelor of Technology in Petroleum Engineering to Presidency University, Bengaluru in the month of June, 2022. The results embodied in this report have not been submitted to any other University or Institute for the award of any degree or diploma.

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## **ABSTRACT**

Drilling fluids as an essential chemical in the oil industry is widely applied in all drilling operations. A recent survey revealed that despite the incessant incidents of drilling equipment failures in service, corrosion assessment of drilling mud has been neglected. Hence, correlation between its chemical composition, properties and corrosion effect is lacking. Against this backdrop therefore, the corrosion effects of drilling mud on mild steel, the major component of drilling equipment used in the oil industry was undertaken in order to establish hindsight of the basic concept of drilling fluid corrosion; and proffer necessary and acceptable Preventive measures. Specimens were exposed to salt water mud, oil base mud and borehole water environments. The weight losses and corrosion rates were evaluated at intervals of sixty-four days using the weight loss. Corrosion in various forms is the major cause of drill pipe failures that add significantly to drilling costs. The trends toward drilling of deeper wells, use of higher strength steels, presence of higher stresses, and use of lower pH drilling fluids contribute to increased susceptibility of metals to failure because of corrosion. Corrosion is the principal cause of damage to metals in wells and production facilities. Corrosion damage results in costly maintenance of these facilities and the loss of production. Corrosion attacks metals in drilling and producing operations through electrochemical processes in the presence of electrolytes and corrosive agents in drilling, completion, packer, and produced fluids. The components in fluids that promote the corrosion of steel in drilling and producing operations are oxygen, carbon dioxide, hydrogen sulfide, salts, and organic acids. Destruction of metals is influenced by various physical and chemical factors that localize and increase corrosion damage.

[Keywords: Drilling fluids, Corrosion, Additives, Drillpipe damage, pH, Preventive measures]

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## **ABBREVIATIONS AND ACRONYMS**

WBM	-	Water-Based Mud
OBM	-	Oil-Based Mud
SBM	-	Synthetic-based fluid
MWD	-	Measuring While Drilling
LWD	-	Logging While Drilling
ROP	-	Rate of Penetration
pH	-	Potential of Hydrogen
CMC	-	Carboxy Methyl-Cellulose
EDTA	-	Ethylenediamine tetraacetic acid
EBT	-	Eriochrome Black T
EMFR	-	Electro Magnetic Force Restoration
TDS	-	Total of dissolved solids
DDW	-	Deuterium Depleted Water
ATC	-	Automatic Temperature Controller
DO	-	Dissolved Oxygen
KI	-	Potassium Iodide
RD(in graph)	-	Rod
mpy	-	Miles per Year
ppm	-	Parts per million
BOD	-	Biochemical Oxygen Demand
pKa	-	Acid Disassociation Constant

# **CHAPTER 1**

## **INTRODUCTION**

# Chapter 1: Introduction

## 1.1 What is drilling fluid?

Drilling fluid, sometimes referred to as drilling mud, is often used to facilitate well drainage. Drilling fluids are often employed while drilling for oil and gas wells, and they are also utilized for much simpler boreholes, such as water wells, in the area of exploration.

Drilling fluid is classified into three types: Mud made of water that can be disseminated or not. Non-aqueous mud, also known as oil-based and gaseous drilling muds, can contain a variety of gases. They are used to dig various oil and gas formations, combined with appropriate polymer and clay additives, with their moulding agents.

Drilling fluids serve a variety of purposes, including preventing formation fluids from entering the well bore, keeping the drill bit cool and clean during drilling, transporting drill cuttings, and suspending drill cuttings while drilling is paused and the drilling assembly is brought in and out of the hole. To reduce formation damage and limit corrosion, the drilling fluid utilized for a specific project is chosen.

### 1.1.2 Types of Drilling Fluids

**Water-based mud (WBM):** Most water-based mud systems start with water, then add clays and different chemical compounds to make a homogeneous mixture that tastes like a cross between chocolate milk and malt (depending on viscosity). The clay is often a blend of natural clays suspended in the drilling fluid or specific varieties of clay collected and provided as WBM system additives. The most common additive is bentonite, which is often recognized as "gel" in the oilfield, is the maximum usual of them. When a fluid is pumped, it can be very thin and free-flowing (like chocolate milk), but when the pump is turned off, the static fluid forms a "gel" structure that prevents flow. Flow restarts and the fluid returns to its original free-flowing state when the enough pumping power is provided to "break the gel. Other chemicals (such

as potassium formate) are added to a WBM system to produce a variety of benefits, such as viscosity control, shale stability, increased drilling rate of penetration, and equipment cooling and lubrication.

**Oil-based mud (OBM):** An oil-based mud is one that uses an oil-based base fluid like diesel fuel. Higher lubricity, shale inhibition, and cleaning powers with reduced viscosity are all reasons why oil-based muds are used. Oil-based muds are also more heat resistant. Cost, environmental issues such as cuttings disposal in a suitable location, and the exploratory drawbacks of utilising oil-based mud, especially in wildcat wells, are all factors to consider when employing oil-based mud. Because the base fluid cannot be differentiated from oil retrieved from the formation, Geochemical analysis of cuttings and cores is performed using an oil-based mud, and API gravity is calculated.

**Synthetic-based fluid (SBM):** A synthetic-based fluid is a mud using synthetic oil as the basic fluid. Because it has the qualities of an oil-based mud, it's far typically hired on offshore rigs, even though the fluid fumes are extensively much less dangerous than an oil-based fluid. This is critical when the drilling team is working with fluid in a confined location like an offshore drilling rig. Oil-based fluid has the same environmental and analytical issues as synthetic-based fluid.

### **1.1.3 How to select the drilling fluid?**

In general, there are three key factors normally decide the kind of drilling fluid selected for a particular well:

1. Cost
2. Technical Performance
3. Environmental Impact

### **1.1.4 Composition of drilling fluid**

Bentonite clay (gel) plus additions like Barium sulphate (Barite), Calcium carbonate (chalk), or Hematite are the most prevalent components of water-based drilling mud. Xanthan gum, guar gum, glycol, or starch are among the thickeners used to modify the viscosity of the fluid. Other often additives include lubricants, shale inhibitors, and fluid loss additives.

A weighting agent like Barite is added to enhance the total density of the drilling fluids. In order to avoid an unplanned (and potentially deadly) entry of formation fluids, sufficient bottom hole pressure can be maintained. The usage of high-pressured and high-temperature silica and clay nanoparticles assists in the formation of Invert emulsion-based muds, as well as the monitoring their favourable impact on the rheology of drilling mud.

#### **1.1.4.1 Composition of water-based drilling fluid**

The performance of mud additives is affected by the quality of water used to manufacture and maintain water-based muds. In fact, clay minerals work great while blended with fresh water. Clay is less effective with hard as well as saline waters.

Spud muds: The mud often used spud a well varies according to the drilling methods adopted throughout the world. In some circumstances, the operator uses only water from a nearby source, such as a well, stream, or, on the other hand, a lake. When the makeup water is soft and the formations at the surface form a good natural mud, this is the optimal setting. If this isn't the case, the operator can add clay, lime, or soda ash to the mud.

Natural muds: If there is enough clay on the surface, it could be mixed with water to form a wonderful natural mud. Natural muds with low weight and viscosity are helpful at shallow depths, such as for surface drilling and producing holes below the conductor casing, since they either do not hydrate well or require a lot of water to maintain their weight and viscosity low. Formation pressures are normally normal in shallow holes; therefore, mud does not need to be thick to avoid kicks.



#### 1.1.4.2 Composition of oil-based drilling fluid

Instead of water, the liquid phase of oil muds is oil, commonly diesel or synthetic oil. Oil-based muds are more costly, more difficult to handle, and more difficult to dispose of than water-based muds, but they are easy to create and manage. Operators only utilise them when the downhole circumstances necessitate it because to expense and environmental considerations.

Oil muds are often used by operators for the following purposes:

- i. Protecting producing formations,
- ii. Drilling water-soluble formations,
- iii. Drilling deep, high-temperature holes,
- iv. Helping to salvage casing (when used as a casing pack),
- v. Mitigating severe drill string corrosion,
- vi. Preventing entrainment of gas and
- vii. Drilling troublesome shales.

#### 1.1.4.3 Composition of synthetic-based drilling fluid

In contrast to the base oils in OBM (diesel and mineral oil), which are refined from crude oil, the base fluids in SBMs are synthetic organic compounds that operate like petroleum-derived oils in terms of drilling but, according to the manufacturer, biodegrade rapidly in seawater. SBMs are inversion emulsions, with the synthetic fluid serving as the exterior, or continuous, phase and a brine acting as the interior phase, similar to most OBMs.

Several synthetic fluids, all in the C<sub>18</sub>-C<sub>24</sub> size range, have been launched onto the market in recent years:

**Ester<sup>2,3</sup>:** Derived by the interaction of a fatty acid with an alcohol. [the ester may be regarded a synthetic vegetable oil]

**Di-Ether:** Condensation and partial oxidation of alcohols resulted in the formation of di-ether; the di-ether was preceded by a mono-ether [lower molecular weight di-ethers are used as solvents, cosmetics, perfumes, and flavouring agents.

### **1.1.5 Purpose of drilling fluid**

Cuttings are generated during drilling, although they are usually not a concern till the drilling is shut down due to a drillbit breakdown or another issue. When this occurs without using drilling fluids, the cuttings re-fill the hole. Drilling fluids are used as a suspending device to avoid this. As movement slows, overall viscosity of drilling fluid increases, allowing the fluid to offer a liquid consistency while drilling and then convert into a more solid material once drilling is completed. The cuttings are then suspended in the well until the drill is reinserted. When drilling restarts, the gel-like substance returns to a liquid form.

Drilling fluids additionally help in controlling bore stress by regulating hydrocarbon and rock wellbore stability. Drilling fluids contain weighting substances that enhance the flow of fluids but also, as a result, the pressure it exerts on the well sidewall. Rock stability is another important aspect of hydrocarbons. Special additives are used to ensure that perhaps the drilling mud is not drained by the well's geological formation yet its holes are also not sealed.

As deeper a well is drilled, greater drill pipe is utilised. Drilling mud enhances stability and decreases stress since so much drill pipe is weighty. By reducing friction only with geological formation, drilling mud additionally significantly reduces temperature. A drillbit's duration gets extended by greasing as well as chilling it.

### **1.1.6 Drilling fluid system**

A steady working fluid as well as an interrupted particles stage exist in drilling fluid systems. These get a vapor from period to period, either through construction or because of spontaneous production vapor entrainment. Through using continuous phase, drilling mud may be categorized into three parts: gaseous, aqueous substances, and non-aqueous substances. These substances are made up of a combination of semisolid particles, each of which can be designed to vary either viscosity or density of such drilling fluid.

One of most common as well as diversified of such three forms of drilling fluids include aqueous drilling fluids, commonly referred to as “drilling fluids. These might

be as simple as water mixed silt to complex inhibitive, or silt stabilized, drilling fluid systems with numerous elements. During past few decades, scientists and engineers have already been attempting significantly to enhance both inhibitive as well as thermal efficiency of water solutions in strategies to succeed against non-aqueous fluids, that are frequently used during problematic pumping situations.

Mineral oils, biodegradable esters, olefins, and other types can be found in the continuous phase of non-aqueous drilling fluids, often known as synthetic-base muds. Although more expensive than aqueous drilling fluids, these systems have better borehole control, thermal stability, lubricity, and penetration rates, which may help the operator save money overall. Drillers utilise air, mist, or foam systems to assist remove cuttings from the hole and preserve wellbore integrity in fractured rock or settings where the borehole cannot hold a column of water without considerable fluid loss to the formation.

## **1.1.7 Functions of drilling fluids**

### **1.1.7.1 Removal of cuttings from well**

Drilling fluids which are thixotropic are perhaps the most frequent (viscosity increase during static conditions). The above properly performed those cutting stationary whenever the fluid is just not flowing, mostly for servicing.

Fluids containing significant varying densities as well as shear weakening seem to be excellent during drilling operations. Increasing annulus speed improves cutting efficiency. It is recommended that appropriate half of both the transfer rate (carrying speed / minimum annular speed) is maintained.

Highly dense fluids will successfully wash pores also at modest annulus speed (by increasing the buoyancy force acting on cuttings). Yet, once mud weight surpasses which necessary to equalize this same pressure with neighbouring rocks (formation pressure), it also has a negative impact, and this is why moisture content of the soil is typically increased for proper well wash.

### **1.1.7.2 Suspend and release cuttings**

Drill cuttings, weight materials, as well as additives should be hung in such wide range of situations. Drill cuttings that settling may create dams as well as fill, blocking pipelines and restricting flow. Sag indicates that weight material gradually sinks, creating a significant variation mostly in density including well fluids. This is more prevalent in greater angle as well as hot wells.

To ensure proper sediment control, drilling particles should be removed from fluid during the first rotation of the well. While cuttings are re-circulated, they broken down into various parts and get harder to eliminate. Mostly in pipeline system as well as in the suction pits, make a comparison of the sand content in the clay (to determine whether cuttings are being removed).

### **1.1.7.3 Control formation pressure**

Mud thickness may be increased when formation pressure increases to regulate pressure as well as to keep the borehole steady. One of the most commonly used weighing elements is barite.

Imbalance formation pressures may create an unexpected influx (also known as a kick) of formation fluids through the borehole, potentially leading towards a blowout via compressed formation fluids. Drilling fluid density\*true vertical depth\*gravitational accelerates the Hydrostatic pressure is the same as atmospheric pressure. When hydrostatic pressure exceeds or equals formation pressure, formation fluids will never ever flow into to the borehole. Unrestrained formation fluid stream into a wellbore is referred to as well control. Hydrostatic pressure governs the loads imposed by tectonic forces, which could also make wellbores unsteady although when formation fluid pressure is equal.

If somehow the formation pressure has become too low, oxygen, vapor, fog, stiff foam, or low-density mud should be used (oil base).

#### **1.1.7.4 Seal permeable formations**

If mud chamber pressure increases formation pressure, mud filtrate infiltrates through formation as well as deposits a filter cake of mud on its bottom of the borehole. Mud is designed to keep invaders at bay by forming a thin, low-permeability filter cake mostly on the surface. Whenever a thick filter cake occurs, it causes tight hole situations, poor log quality, blocked pipeline, delayed flow, as well as formation damage. Entire mud may permeate exceedingly permeable formations having big bore mouths, vary according to the size of the mud particles; utilize bridging compounds to plug big holes, then mud particles can create a seal. Of being functional, bridging substances should be at least half the size of the pore spaces / fractures. Various bridging compounds include calcium carbonate, powder form cellulose, as well as other binders.

Depending on the drilling mud, a range of additives (such as bentonite, natural and synthetic polymer, asphalt, and gilsonite) can improve the filter cake.

#### **1.1.7.5 Maintain wellbore stability**

Chemical composition and mud characteristics should help to produce a steady borehole. The quantity of the mud should be within a specified limit in order to maintain the mechanical load. Wellbore instability manifests itself in the form of sloughing formations, which can cause tight hole situations, bridges, and fill on excursions (same symptoms indicate hole cleaning problems). Borehole stability refers to the hole's shape and size being constant. When a hole gets wider, it becomes weaker and more difficult to stabilize, resulting in problems such as low annulus velocities, poor hole cleaning, particle loading, as well as poor formation evaluation. Chemical inhibitors (calcium, potassium, salt, polymers, asphalt, glycols, and oil – good for water-sensitive deposits) could be used to reduce mud/shale contacts.

As lowering moisture content as well as producing osmotic pressures, emulsified brine phase (calcium chloride) drilling fluids are employed to prevent water adsorption in Shale formations.

### **1.1.7.6 Minimizing formation damage**

Any decrease in natural formation porosity and permeability is described as formation damage (washout). Skin damage is caused whenever residuals accumulate on perforations, producing a drop in pressure through them.

The following are the most prevalent areas where damage occurs:

- 1) Mud or drill solids permeate the formation matrix, causing skin irritation and lowering porosity.
- 2) Decreased permeability owing to swelling of formation clays within the reservoir.
- 3) The mixture of mud filtrate and formation fluids causes the precipitation of insoluble salts.
- 4) The reservoir porosity is reduced by an emulsion generated by mud filtrate as well as formation fluids.
- 5) Drilling fluids, as well as work over as well as finishing fluids, are carefully designed to prevent formation damage.

### **1.1.7.7 Cool, lubricate, support the bit & drilling assembly**

Mechanical as well as hydraulic forces generate heat, whenever the drill string circles as well as scrapes against the casing and borehole. Reduce the source of heat and maintain the temperature less than the bottom hole. Drill bits, drill strings, as well as mud engines would mostly wear out faster if this wasn't the case. Lubrication is done using the coefficient of friction. ("The amount of friction on the wellbore side and collar or drill pipe size necessary to extricate stuck pipe is referred to as "coefficient of friction"). Mud that is water-based lubricates better than mud that is oil- or synthetic-based (but the latter can be improved by the addition of lubricants). The type and volume of drill solids as well as weight materials, as well as the chemical composition makeup of the system, affect how much lubricating drilling fluid provides.

Appropriate lubrication causes high torque as well as drag, as well as heat testing of the drill string, however these difficulties can also be created by key seating,

inadequate hole washing, as well as incorrect bottom hole assembly design. Drilling fluids also include a segment of the drill string or casing buoyancy. Suspend derrick hook load in drilling fluid, sustained by a force equal to the weight (density) of the mud. A derrick's mechanical capacity limits the amount of weight it can support; as depth grows, so does the weight of the drill-string as well as casing. When utilizing long, heavyweight strings or casing, buoyancy can be employed to carry casing strings stronger than the rig's hook load capacity.

#### **1.1.7.8 Transmit hydraulic energy to tools & bit**

The mud engine, which turns the bit, as well as the MWD and LWD (measurement and logging while drilling) machinery, are powered by hydraulic energy. By designing bit nozzles for existing mud pump horsepower, hydraulic programs maximize jet impact at the bottom well.

Restricted to:

- 1) Pump up the power,
- 2) Drill string pressure loss,
- 3) Highest surface pressure that can be applied,
- 4) The rate of flow,
- 5) Drill string pressure losses are larger when fluids have greater density, plastic viscosities, and particulates.

Drilling fluids having fewer particles and less shear thinning, including polymer fluids, are more effective at conveying hydraulic energy. Managing mud properties might help you go deeper. Data is sent from MWD and LWD to the surface via pressure pulses.

#### **1.1.7.9 Ensure adequate formation evaluation**

Different physical and chemical mud properties, as well as borehole conditions after drilling, all impact formation evaluation. Mineral content, observable indicators of hydrocarbons, rock properties, ROP, gas detection, as well as geological properties

are all things mud loggers search for in cuttings. Wireline logging employs a variety of techniques, including electrical, acoustic, nuclear, as well as magnetic resonance. The probable producing zone is subjected to formation as well as drill stem analysis. By keeping cuttings from spreading as well as increasing cutting transportation, mud aids, mud loggers in determining the depth of the cuts. Oil-based soil, lubricating oils, as well as bitumen will conceal hydrocarbon indications. As a consequence, the drilling core is selected depend on the type of evaluation to be undertaken (many coring operations specify a bland mud with minimum of additives).

#### **1.1.7.10 Control corrosion**

Corrosion might occur if the drill string as well as casing are exposed to drilling fluid on a regular basis. Corrosion is accelerated by dissolved gases (oxygen, carbon dioxide, and hydrogen sulphide). Create a catastrophic breakdown in a short amount of time. It is possible that it will be lethal to humans within a short period of time. Because low pH (acidic) makes corrosion worse, use corrosion coupons to maintain count of the type, rate, as well as quantity of chemical inhibitor used. A corrosion coupon is a small bit of metal that has been exposed to corrosive environments to observe how it affects related machinery of similar composition. Mud aeration, foaming, and other O<sub>2</sub> trapped situations cause corrosion problems in a very brief span of time. During drilling in high H<sub>2</sub>S environments, increased pH fluids and sulphide scavenging chemicals were used (zinc).

#### **1.1.7.11 Facilitate cementing & completion**

Cementing is required for a zone and also well completion to be accomplished. The mud must remain fluid during the casing run, as well as pressure increases must be minimized to prevent fracture-induced lost circulation. The temperature of the cementing fluid is within the cementers' limitation, which is generally 70 degrees, especially in cold climates. A thin, smooth filter cake with few particles, a wellbore with few cuttings, as well as no caves or bridging to obstruct a proper casing run to the bottom are all desirable characteristics in mud. Circulate until the bore is free of



obstructions. To adequately cement as well as to accomplish the operation, mud is displaced by flushes as well as cement. We attempt to ensure the following for effectiveness:

- a) When drilling near gauges, use proper hole cleaning methods, pumping sweeps at TD, and wiper trip to shoe.
- b) Mud with low viscosity, mud features that are tolerant of the deposits being drilled and the drilling fluid composition, turbulent flow with low viscosity as well as high pump rate, laminar flow with high viscosity as well as high pump rate,
- c) Mud with low viscosity and low pump rate,
- d) Mud's gel strength does not increase over time.

#### **1.1.7.12 Minimize impact on environment**

Mud may be hazardous in a variety of ways. It's also difficult and expensive to get rid of it in an environmentally friendly manner. According to Vanity Fair, drillers at Lago Agrio, Ecuador's largest oil field, worked virtually unsupervised. Water-based drilling fluid is often found in Wyoming and Telemark, and is made up of water, bentonite, and barite, all clay from mining activity. When used alone with water-based drilling fluids, hydrochloric acid, for example, is caustic and dangerous. When applied to water-based drilling fluids, hydrochloric acid simply lowers the pH to a more bearable level. Caustic (sodium hydroxide), anhydrous lime, soda ash, bentonite, barite, and polymers are the most often utilized components in water-based drilling fluids.

Oil base mud and synthetic drilling fluids include significant levels of benzene and other chemicals.

Some of the most prevalent chemicals utilized in OBM Muds.

- a. Barite,
- b. Bentonite,
- c. Diesel,
- d. Emulsifiers and
- e. Water.

### 1.1.8 Factors effecting drilling fluids

Drilling fluid performance is influenced by a variety of parameters, including,

- a) Fluid Rheology
- b) Drilling fluid viscosity
- c) Drilling fluid density
- d) Mud pH
- e) Drill string corrosion or fatigue
- f) Drilling fluid thermal stability
- g) Differential Sticking

### 1.1.9 Drilling fluid life cycle

Drilling fluid design and maintenance are iterative procedures driven by surface and downhole variables. When the well is dug deeper into the formation and encounters successive increases in temperature as well as pressure, as well as chemical changes produced by different types of rock and formation fluids, these conditions alter (above). On-site fluid specialists and staff engineers use continuous process engineering to fine-tune the drilling fluid in response to changing borehole conditions, then analyse fluid performance and change fluid parameters in a loop.

**Initial design:** Throughout the planning phase, fluid specialists select the kind and design of mud system for each drill section. The systems are designed to meet a wide range of requirements, including as density, borehole stability, temperature gradients, logistics, and environmental concerns. To begin drilling, a rudimentary fluid system might be employed. Water is commonly used when drilling to the first casing point. As the borehole deepens, greater formation pressure, rising temperatures, and more complex formations need increased mechanical wellbore control and hole cleaning capacity. Simple fluid systems can be displaced or changed into weighted water-base inhibitive mud, which is subsequently followed by non-aqueous drilling fluids at greater depths.

**Circulation:** The drilling fluid's composition shifts over time. In a single circulation cycle, the fluid squandered energy by lifting cuttings, cooling the bit and hole, and finally dumping trash to the surface. Engineers and fluid specialists must evaluate the system on a regular basis and supply it with fresh fluids and additives.

**Measurement and redesign:** The specialist in drilling fluids evaluates the mud that has been returned. Density, rheology, filtration rate, continuous phase content and ratios, and solids content and classification are only a few of the factors that are evaluated, and they differ based on the fluid type. pH, hardness, alkalinity, chlorides, acid gas concentration, and other fluid-specific variables are all measured. The doctor then devises a 12-to-24-hour therapy regimen. The driller, derrickman, and fluids specialist maintain a careful check on borehole conditions and the qualities of the returning fluid, and modify the mud as needed depending on the hole and drilling conditions

### **1.1.10 Drilling fluid classification**

The fluid phase, alkalinity, dispersion, and chemical makeup of these materials are used to classify them.

#### **1.1.10.1 Dispersed system**

Organic colloid-treated mud. A pH of above 9.5 is seen in alkaline tannate treated muds, for example. High pH lime muds, low pH gypsum muds, seawater, and saturated salt water muds are four types of water-based drilling muds that impede clay hydration and dispersion.

#### **1.1.10.2 Non-dispersed system**

1. **Low Solids Mud:** Low solids mud has a solids content of 3–6% by volume and weight less than 9.5 pounds per gallon. The bulk of these muds are water-based, with various proportions of bentonite and a polymer.

2. **Emulsions:** Emulsions are two types of emulsions that are used: oil in water (oil emulsion muds) and water in oil (invert oil emulsion muds).
3. **Oil-Based Muds:** Oil is the continuous phase of oil-based muds, and water is a contaminant rather than a design feature. They generally contain less than 5% water (by volume). Oil-based muds are often manufactured from a mixture of diesel fuel and asphalt, although they can also be made from crude oil and mud.

### 1.1.11 DRILLING FLUID PROBLEMS

Each well has its unique set of challenges. The formation's rock type, well pressures and temperatures, and contaminants that affect the fluid are all possible issue areas. The mud engineer tailors the drilling programme for each well to extract the petroleum in the most efficient and cost-effective way possible while maintaining formation pressure control. Unfortunately, in attempting to get the best performance for all of the functions that a drilling fluid must do, the mud engineer falls across problems. For example, weighting a mud to promote optimal cuttings conveyance risks fracturing the deposit. Drilling experts are always weighing the benefits and drawbacks of changing a drilling fluid.

#### 1.1.11.1 Drilling in shale formations

Despite being a porous rock, shale has a low permeability. However, salt water and other fluids such as hydrocarbons are regularly present in the pore spaces. The salt water is connate water that was present in the formation when it developed. In a few cases, hydrocarbons can be discovered in impermeable shale. Huge shale reserves in the western United States, for example, include hydrocarbons that can't be extracted by drilling. These deposits will be mined or exploited in some form when the time comes. In any event, when a wellbore exposes shale to drilling fluid and the shale includes salt water, the drilling fluid must be handled with extreme caution.

### **1.1.12 Testing of water-based drilling fluids**

On land rigs, the derrickhand inspects the mud for weight, viscosity, as well as temperature fluctuations, as well as changes in cutting size, flow rate, and mud level in the tanks. More extensive testing is carried out by a mud engineer. The most typical mud qualities examined by the derrickhand include density, viscosity, and gel strength, filtration and wall-building, and sand content. The mud engineer may examine the mud's pH, liquid and solid content, contaminants, and electrolytic properties. The corrosion of the metal components in the hole is hastened by mud that conducts an electric current. Whoever tests the mud also keeps a mud journal of the results.

The API publications 13B-1 and 13B-2, Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids and Oil-Based Drilling Fluids, give thorough descriptions, equipment, and methods for testing water-based and oil-based drilling fluids, respectively. These ideas are expanded upon in the following information.

#### **1.1.12.1 Preparing mud samples**

To obtain accurate and meaningful mud test results, the samples must replicate the mud downhole, so most experiments replicate some or all of the well conditions. Some tests, for example, require the mud to be churned or disturbed to simulate circulation, while others require the mud sample's temperature to be close to that of the borehole.

### **1.1.13 Treatment of drilling fluids**

The crew and mud engineer test the mud to see if it needs to be treated and when. Depending on the drilling conditions, the mud's composition or weight may need to be altered.

### **1.1.13.1 Breakover**

Changing the mud chemistry from one type to another is critical in many drilling operations. A conversion, also known as a breakover, is the technical term for such a transition. The point at which the mud's properties truly change is known as breakover. When switching from one type of mud to another, a breakover usually involves a significant change in mud chemistry, as well as severe "viscosity humps. A salt-saturated mud system can be created by adding salt to a traditional bentonite-based mud system. As you add salt, the viscosity will rise dramatically, reaching extremely high levels, but you will eventually reach a breakover point where the viscosity begins to fall as you add more salt. You're switching from one type of mud system to another.

Breakovers are done for a variety of reasons, including the following:

- 1) Keeping a steady wellbore,
- 2) Providing a mud that can withstand greater weight,
- 3) Salt formations are being drilled,
- 4) Reducing the amount of clogging in the producing zones.

Breaking over mud in an open hole can be dangerous in some situations due to the high viscosities commonly observed. In a cased hole, a breakover is usually performed before drilling the next hole segment.

### **1.1.14 Formation choice of drilling fluid**

The rheology of drilling fluid has an influence on how well it drills. The efficacy or performance of a drilling fluid is measured by its ability to do its mission. The drilling fluid's main purpose is to remove formation cuttings from the well. While in circulation, the cuttings should be transported and suspended in the prescribed fluid, and securely transmitted through the annulus with minimal losses and environmental impact.

During the selection and formulation phase, the mud engineer determines the required viscosity, density, fluid loss control, chemical composition, and many other elements of the fluid. The cost, technical performance, and environmental impact on the

formation are three important factors that determine the type of drilling fluid used. The selection of the best-fitting type is crucial since it impacts the success of the drilling operation. Researchers have focused their efforts in recent years on producing a biodegradable oil base-mud that would cut disposal costs while also reducing environmental impact.

The fluid pump represents the heart, drilling fluid represents the waste materials ejected from the body through the blood arteries, and the kidney and lungs symbolize the mud-cleaning system. In the oil exploration and extraction industry, drilling activities are expected to account for 50 to 80 percent of exploration costs and 30 to 70 percent of other field development costs.

Drilling fluids are particles suspended in water or oil that may be mixed with additives to make them more effective.

The principal roles of drilling fluids include:

1. Carry cuttings from below the bit, move them up the annulus, and separate them at the surface,
2. Cool and clean the drilling bits,
3. Create a thin, low-permeable filter cake that covers pores and other openings in bit-penetrated formations to reduce friction between the drilling string and the side of the hole, maintain the stability of uncased areas of the borehole, and prevent fluid intrusion from permeable rocks penetrated,
4. Assist in the collection and analysis of data from drilling cuttings, cores, and electrical logs.

### **1.1.15 Environmental impact of drilling fluids**

When drilling exploration and production oil and gas wells, muds, or specialized drilling fluids, are used to help maintain well control and remove drill cuttings from the drill hole. In response to current global environmental challenges, as well as strict international and local regulations on drilling waste discharge requirements, the drilling industry has recently developed several types of synthetic-based fluids. These

fluids combine the desirable operating qualities of oil-based drilling fluids with the lower toxicity and environmental impact qualities of water-based drilling fluids.

While oil-based fluids are beneficial in areas prone to shale swelling, when discharged and then transported into the sea, they have a harmful impact on the ecosystem. Aquatic creatures, such as plants and fish, are severely harmed. This will harm the environment in the long run. Furthermore, the fish are venomous and dangerous when consumed by humans. Furthermore, toxins produced during onshore drilling may have a significant impact on soil quality, changing the soil's chemical features and, as a result, people's habitat and animals. When discharged beneath water, cuttings from oil-based fluids disperse less than cuttings from water-based fluids. It will construct cutting piles to cover portions of the seabed. This condition may have an impact on bottom-dwelling species around the rig.

Synthetic-based drilling fluids are a new form of drilling mud that is especially useful for drilling in deep water and in deviated holes. They are a revolutionary form of material that may be used to safely and efficiently drill oil and gas wells. Their increased drilling performance cuts drilling time in half and, in certain cases, outperforms diesel oil fluids in terms of safety, human health, and environmental performance. They were developed as a more environmentally friendly alternative to oil-based drilling fluids.

## **1.2 What is corrosion?**

Corrosion is the corrosion and loss of a material's primary features caused by chemical, electrochemical, and other interactions between the exposed material surface and the surrounding environment.

Metals and nonmetals both corrode as a result of increasing air interaction on their surfaces. The structures and facilities of diverse materials are affected by this interaction. On steel surfaces, even wet, oxygen-rich ambient air can start the rusting process.

The electrochemical oxidation of a metal in the presence of an oxidant such as oxygen, hydrogen, or hydroxide is known as corrosion. Rusting, in which iron oxides



form, is a well-known example of electrochemical corrosion. This type of damage generally results in the production of oxides or salts of the parent metal, which gives it its distinctive orange hue. Corrosion can also occur in other materials such as ceramics or polymers, however the term "degradation" is more usually used in this situation. Corrosion affects the strength, durability, and permeability of materials and structures to fluids and vapours.

### **1.3 Corrosion in drilling fluids**

Corrosion is increasingly a more major global threat to the integrity of oil and gas pipelines, steel base installations, and other infrastructure, leading in financial losses and environmental problems. These types of infrastructure include pipelines, platforms, vessels (storage tanks), drill pipes, and well casings. Economic losses include downtime, production losses, contamination, and equipment failures, whereas environmental risks include pollution, spills, flora and fauna damage, fire breakouts, and deaths. Drilling mud is widely used in the petroleum business, notably in the drilling sector. Drilling mud is composed consisting of solid components suspended in water or oil, or granules and molecules suspended in one of these fluids. Clays and organic colloids make up these substances.

Drilling mud comes in three different types: water-based, oil-based, and gas-based. Solid particles are maintained in fresh or salt water to produce a water base mud. As a result, depending on the type of water, we get freshwater and saltwater mud. Oil base mud is a coring fluid made solely of oil. No additional water or brine is given since oil base muds absorb water from the deposit. Oil base mud systems are distinct drilling muds developed to overcome some of the disadvantages of water base mud, primarily due to water's abilities to dissolve salts, interfere with oil and gas movement through porous rocks, encourage clay, disintegration, and dispersion, and cause steel corrosion. Drilling mud is used to lubricate the drill string, reducing friction, transport, suspend, and drop off cuttings, support the wellbore walls, regulate pressure, and stabilise the wellbore.

## 1.4 Literature survey

Corrosion is turning into an expanding worldwide danger to uprightness of fossil fuel offices of which the significant part is iron (steel) in the company of companion financial destruction and related natural risks (A.K. Samant, 2003). In drilling engineering, consumption of penetrating apparatus is a typical peculiarity. This issue was turning out to be progressively with the advancement of fast and profound well drilling. Use of low solids, no strong stage, saline solution and MMH (mixed-metal hydroxide) drilling liquid to meet the necessity of this cutting-edge penetrating innovation represents a major test since penetrating liquid should have an assortment of added substances with complex structures. Drilling fluids normally will more often show solid destructive(corrosion) impact under high temperature and high tension and pressure (J. X. Zheng and J. M. Zhao, 1993). These offices comprise pipe channels, stages, container (capacity tankers), drill channels and strong housings. The monetary destruction incorporate however are unrestricted to vacations, creation misfortunes, defilement and hardware disappointments; while ecological dangers incorporate contamination, spill, obliteration of greenery, fire episode and fatalities (J.E.O. Ovri, 2004). Late reports have stated that almost 500 penetrating related mishaps happen in China National Corporation every year, of which around 60% are brought about beside corrosion, close to the extensive expense about managing these occurrence and direct misfortunes (B. M. Wei, 1984). In the oil area, especially in the penetrating business, drilling fluid is generally used in excavating activities. Penetrating fluid indicate toward freeze of strong components in oil or water, either of rigid along with drops of particular fluids scattered particularly (API Southern Committee,1981). Such rigids comprise muds along with natural colloids add on to give vital thick and refine properties (H.C.H Darley & George R. Gray, 1988). The drilling liquid is fundamental for finishing the penetrating activity since it could increment oil recuperation and decrease the time expected to acquire the essential creation (Jamal Nasser et. Al., 2013).

The set of three primary kinds of drilling fluids namely water base fluid, oil base fluid and gas fluid. The strong fragments while defer in new water or brine water comprise water base fluid. Henceforth, we possess condensate (freshwater) fluid and brine water fluid in which be reliant upon the idea of the water. Oil base fluid is figured out

along just fuel (oil) as the fluid stage and it is regularly utilized in the act of essence liquid. Despite the fact that oil base fluids get water out of the development, of course not extra water or saline solution is put on. Oil base fluid frameworks be unique penetrating fluids created on-to conquer specific unwanted attributes of water base fluid fundamentally because of the assets about water, for example, it's capacities toward break up salts, in order to slow down the progression of fossil fuel through permeable rocks, toward advance the deterioration along with scattering about clays, along with toward impact erosion about metal (John H. Berry, 2008). The use as regards drilling fluid in the time of penetrating tasks happen chiefly being lube up drill string along these lines lessening rubbing, passage, delay and release fragments, assist the dividers about the wellbore, manage tension along with adjustment as regards the wellbore (John H. Berry, 2008). Conversely, water-based fluids are reasonable, can be effortlessly structured and is ecologically affable (Caenn et. Al., 2011). Shokoya O.S affirmed that the water-based drilling muds are the bulk ideal one of different sorts inferable from their previously mentioned benefits (Shokoya O.S, 1995). Drilling added substances (synthetic) bide typically append to the drilling fluid toward advance need capacities along with substitute within the assets of fluid, that assets incorporate; thickness (mass), consistency, elastic limit, hold capacity, liquid decline and outside pressure. The extremely regularly involved synthetic substances in rotating drilling reside nevertheless unrestricted in accord with Barite ( $\text{BaSO}_4$ ), bentonite clays along with natural synthetic resins. Barites with comparable loading components having peak explicit attraction(gravity) ( $>4.0$ ) came to be utilized toward effectively elevate penetrating fluid thickness, in order to manage development forces, inspect arrangement buckling along with work with tow line expense (Classifications of Fluid Systems, 2008). Drilling muds are getting corrode because of the presence of broken-down gases, like  $\text{O}_2$ ,  $\text{CO}_2$  and  $\text{H}_2\text{S}$ , and disintegration next to substance of chemicals rather than penetrated fragments through the operation. The destructiveness of water-based drilling muds is a significant issue inside the penetrating activity also, is as yet expected exists settled. Headways into penetrating designing represent an extra provocation as the utilization of penetrating fluid due to extreme natural situations. As deep and ultra-deep profound wells, where in the temperature and tension are more, drilling fluids will generally be further destructive. As indicated by one of the oil organizations of China, penetrating muds consume 4 kg of drill pipe per meter profundity. The misfortunes next to consumption were assessed from 20%-half

of the all-out penetrating expense (Z. Wang et. Al., 2013). To manage and relieve degradation, it is important to comprehend how drilling muds beneath down well situation impact the course of erosion and the elements influencing the upsides of the degradation rates. Bentonite clay is append extending to new water fluid(mud) or oil base fluid(mud) as long as the reasons for expanding opening cleaning limit (expanding viscosity), decreasing water drainage or refine in the direction of porous mediums, shaping a channel flow of low porous, advancing opening security within ineffectively bind along with keeping away from either conquering mislaying of movement. The mix assets as regards naturals synthetic(polymers), for example, starch, guar gum, carboxy methyl-cellulose (CMS) and polyanionic cellulosic polymer (REL-PAC) remain utilized inside the course of penetrating fluids in order to decrease refine, settle clay, flocculent penetrated rigids, increment conveying limit as well as unexpectedly extending to fill in for thickener and lubrication (Clark R.K et. Al., 1976). In spite of such vast with essential utilizations of drilling fluid with in drilling tasks, connection linking it is substance configuration, assets and corrosion behaviour is inadequate. This is opposed to that foundation particularly examination is done in order to assess the consumption conduct about drilling fluid and evaluate its impacts over penetrating equipment. Profound well and ultra profound well bore on-land oilfield essentially put in water-based penetrating fluid like potassium and polysulfide drilling fluid, polymer penetrating mud and soaked salt drilling liquid framework. Because of serious penetrating liquid consumption of drill pipe bringing about enormous amount of drill pipe scrap and expansion in drilling expense, erosion assessment test utilizing normal penetrating fluid frameworks was completed to alleviate drilling fluid corrosion, reduce the all-out penetrating expense and improve penetrating wellbeing.

## **1.5 Objectives**

- 1) To study the corrosion behaviour of various water sample collected from different sources.
- 2) To finding the properties of water samples used to prepare drilling fluid.
- 3) To provide suggestion for corrosion prevention.

# **CHAPTER 2**

## **METHODOLOGY**

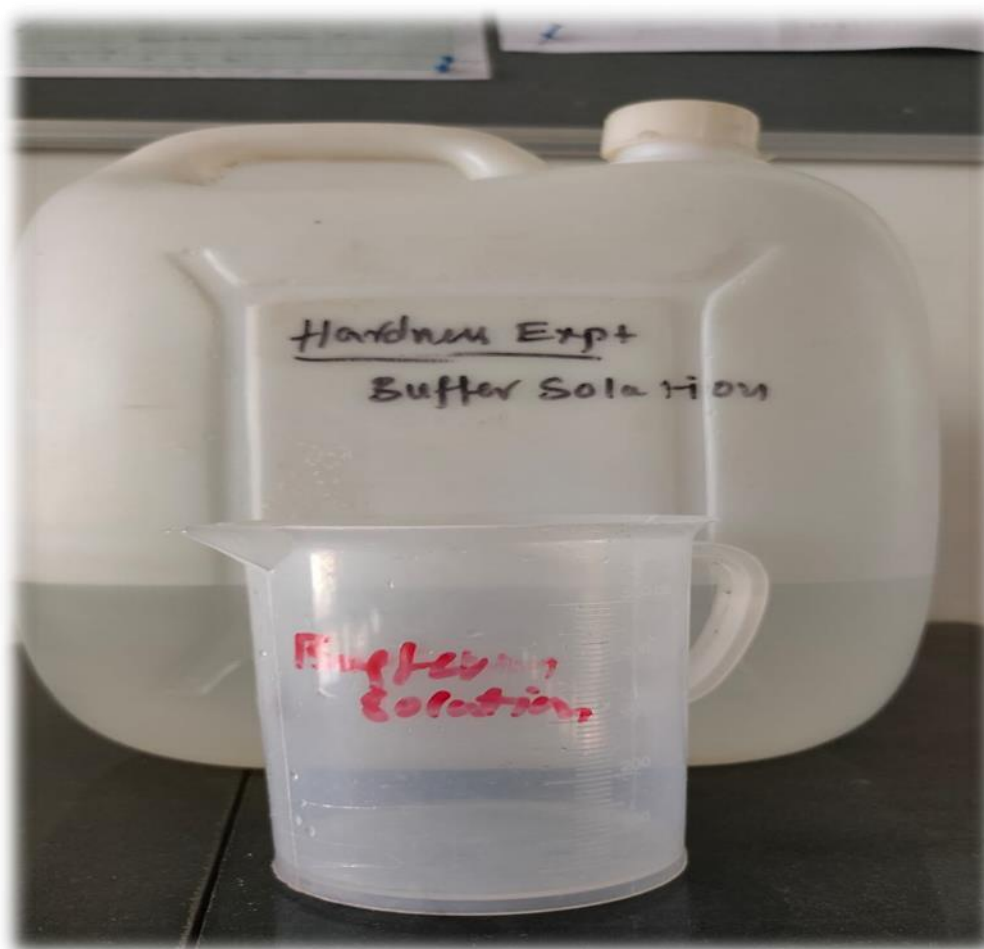
## Chapter 2: Methodology

### 2.1 Chemicals used

The various Chemicals we utilized in this project with various chemicals and indicators are described below:

#### Buffer solution

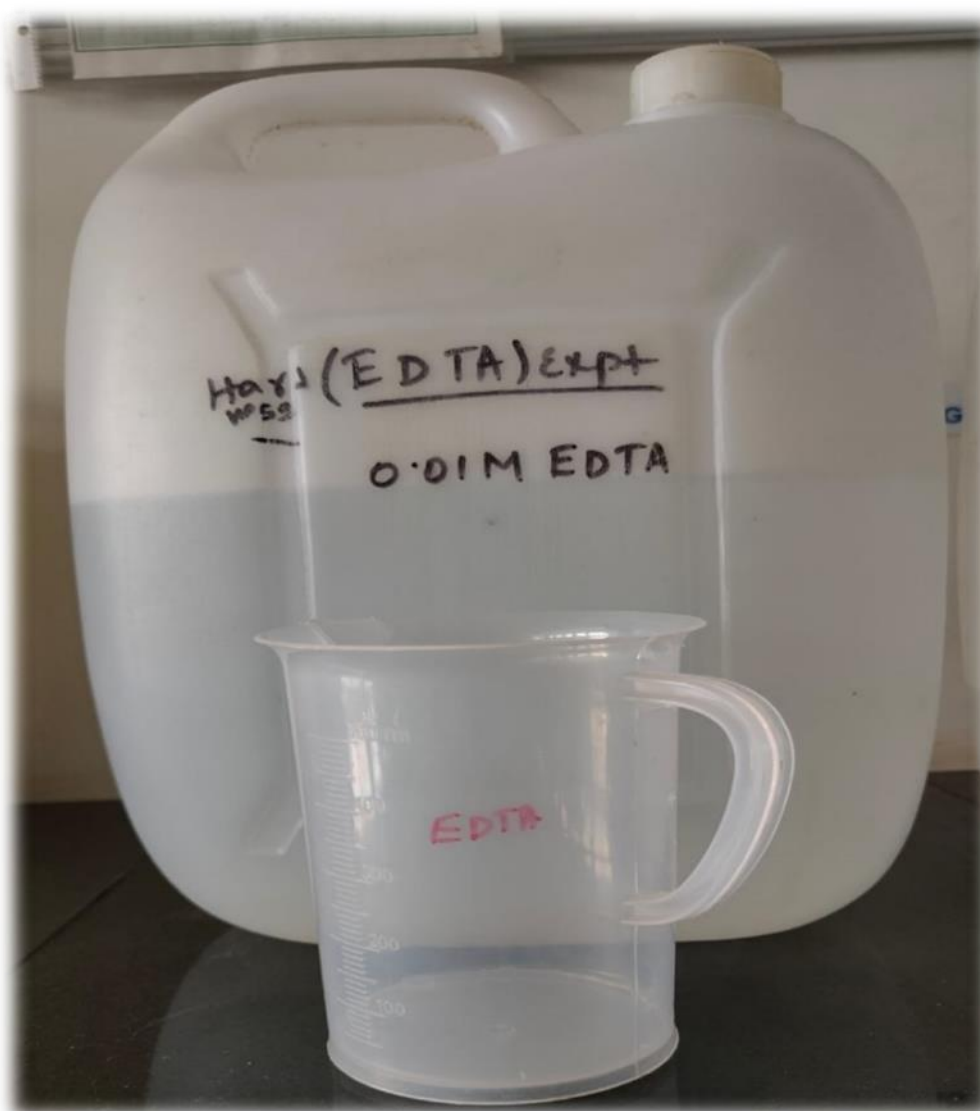
0.1N buffer solution (Nice Chemicals Bangalore). Buffers are solutions with a constant concentration of hydrogen ions, resulting in a pH that is mostly unaffected by dilution and varies very little when a strong acid or alkali is introduced. Because it suppresses pH changes when a small amount of a strong acid or basic is added to it, it's also known as a buffer solution or just a buffer. Both buffers have the same acidity and alkalinity values.



**Fig 2.1(a):** 0.1N Buffer solution

## EDTA

$[\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2]_2$  is the formula for Ethylenediamine tetraacetic acid (EDTA) (Sigma Aldrich, Bangalore). Iron and calcium ions are commonly bound with this water-soluble white solid. These ions are bound by this chelating agent, which has six teeth. The most prevalent salts of EDTA are disodium EDTA, sodium calcium edetate, and tetrasodium EDTA. Ethylenediamine tetraacetic acid (EDTA) is a complexometric indicator made up of two amino groups and four Lewis bases (carboxyl groups). Because it can designate six pairs of lonely electrons due to the creation of covalent bonds, EDTA is referred to as a hexadentate ligand.



**Fig 2.1(b):** Ethylenediamine tetraacetic acid (EDTA)

## HCl ACID

The chemical hydrochloric acid (Allied Chemicals, Bangalore) is inorganic. The synthetic recipe for HCl is a strong destructive corrosive. Other names for it include hydrogen chloride and muriatic acid. When hydrogen chloride is dissolved in water, hydrogen chloride (HCl) is produced. Hydrogen chloride is a strong acid with a high  $K_a$  value. The  $pK_a$  of hydrogen chloride, according to theoretical calculations, is 5.9. Hydrochloric acid is a powerful inorganic acid utilised in a variety of industrial processes, including metal refining. The quality of the product is frequently determined by the application. In industrial organic chemistry, hydrogen chloride is more commonly utilised than hydrochloric acid, for example, in the production of vinyl chloride and dichloroethane.

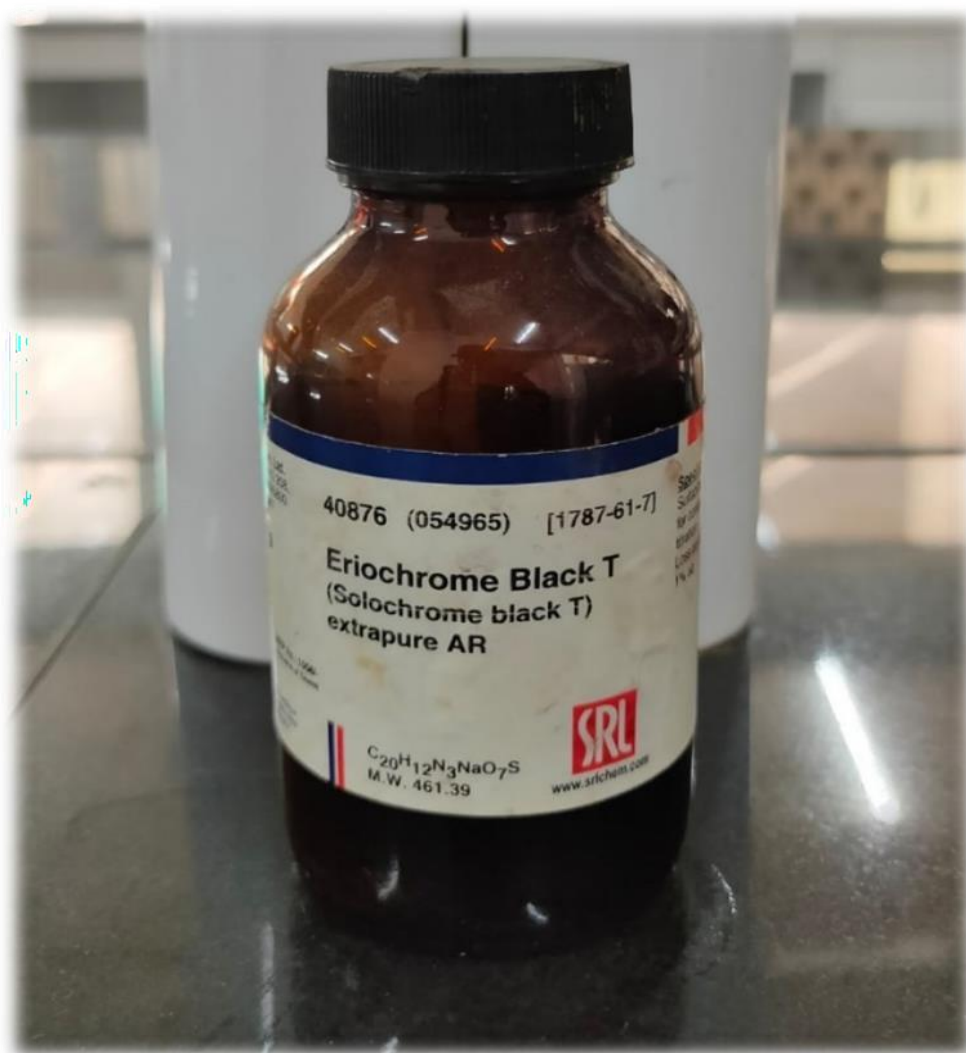


**Fig2.1(e):** HCl acid



## EBT (indicator)

Eriochrome Black T (Bangalore Acids & Chemicals, Bangalore) is used as an indicator in complexometric titrations. It's a pH metre, for those of you who aren't familiar with the term. is a carcinogenic azo molecule that is primarily employed as an indicator in complexometric titrations to determine total hardness of water owing to components such as calcium, zinc, magnesium, and other metal ions. Both  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ions bind to Eriochrome Black T; however, the latter is preferred. In a buffered solution, EBT becomes blue at pH 10. (Aqueous solution containing a weak acid and its conjugate base, or vice versa). It becomes red when  $\text{Ca}^{2+}$  ions are introduced.



**Fig 2.1(d):** Eriochrome Black T EBT (indicator)

### **Methyl orange (indicator)**

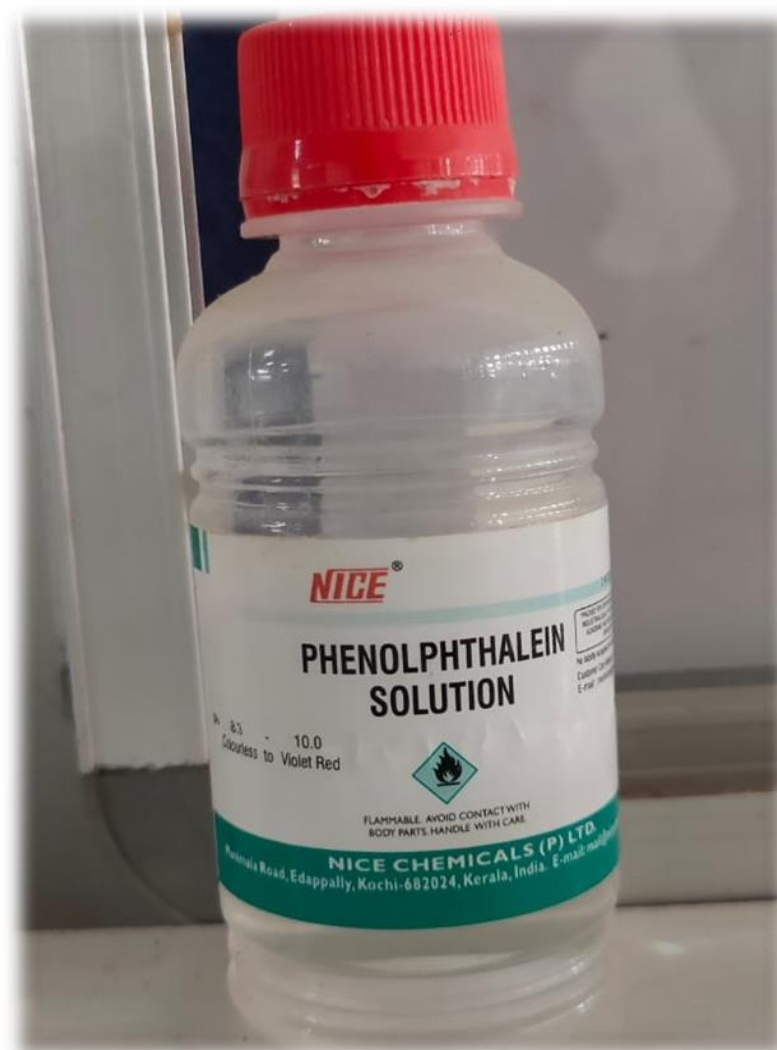
In titration, methyl orange (Karnataka Fine Chemicals, Bangalore) is a commonly used pH indicator. Methyl orange becomes red in an acidic environment and yellow in a basic environment. When the acidity of the solution drops, the colour of methyl orange changes from red to orange to yellow, and when the acidity rises, the reverse occurs. Because of its obvious and vivid colour variance at different pH levels, methyl orange is a pH indicator often used in titration. In an acidic condition, methyl orange turns red, while in a basic media, it turns yellow. Because of the clear and noticeable colour variation at various pH levels.



**Fig 2.1(e):** Methyl orange (indicator)

## Phenolphthalein (indicator)

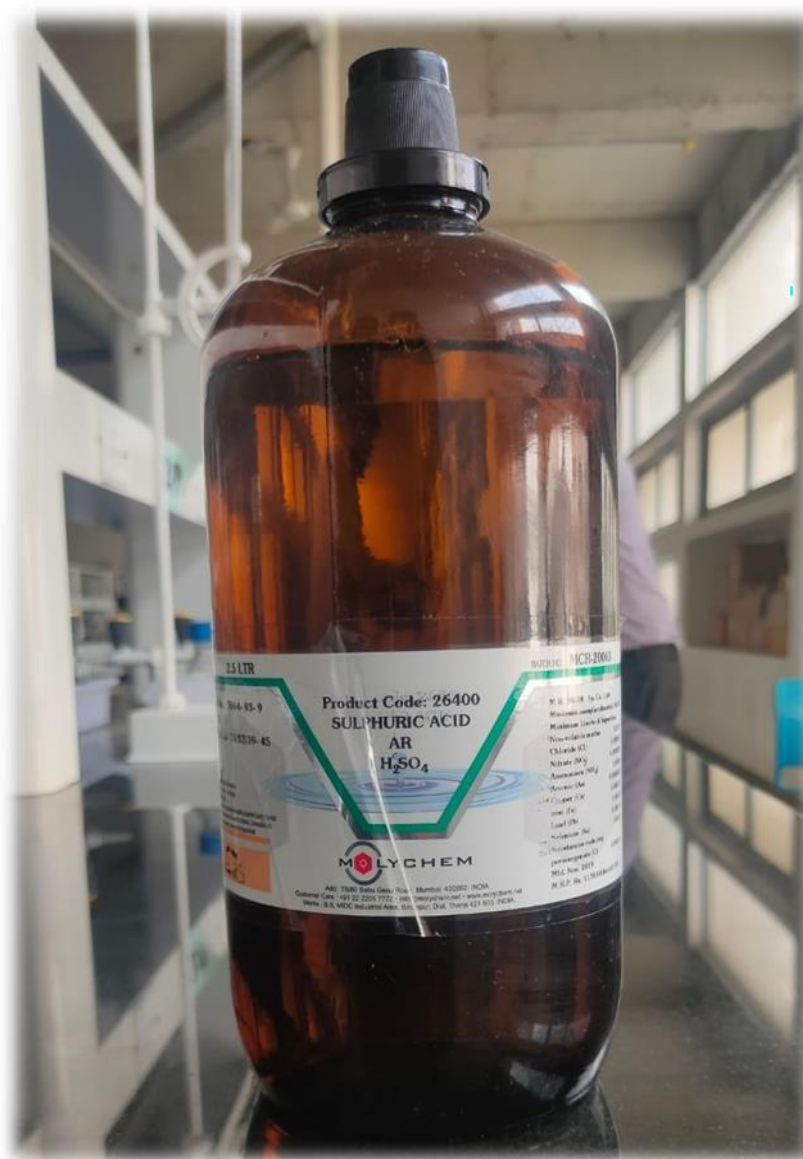
In acid–base titrations, Phenolphthalein (SS Distributors, Bangalore) is a commonly used indicator. It turns colourless in acidic solutions and pink in basic solutions for this purpose. It is a phthalein dye, which is a kind of dye. Phenolphthalein is very marginally soluble in water; thus, it's commonly dissolved in alcohol before being used in investigations. It's a weak acid with the ability to lose  $H^+$  ions in solution. The double deprotonated Phenolphthalein ion is fuchsia while the nonionized Phenolphthalein molecule is colourless. Further proton loss happens slowly at higher pH levels, resulting in a colourless form. Because of sulfonation, the Phenolphthalein ion in concentrated sulfuric acid turns orange red.



**Fig 2.1(f):** Phenolphthalein (indicator)

## Concentrated H<sub>2</sub>SO<sub>4</sub>

Sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) is a strong acid (Allied Chemicals, Bangalore) with hygroscopic and oxidising properties (Karnataka Chem, Bangalore). Sulfuric acid, a mineral acid, with the chemical formula H<sub>2</sub>SO<sub>4</sub>. The sugar is dehydrated with strong H<sub>2</sub>SO<sub>4</sub> to extract carbon and water. The heat of the process causes the water to evaporate, resulting in a carbon column. Sulfuric acid is also known as Mattling acid and Oil of Vitriol. It's corrosive and acidic. At higher concentrations, it exerts oxidising and dehydrating effects. It's a clear, syrupy liquid that has no odour.



**Fig 2.1(g):** Concentrated H<sub>2</sub>SO<sub>4</sub>

## Magnesium sulphate

Magnesium sulphate (Ramdev Chemicals in Bangalore) is a chemical molecule and a salt with the formula  $\text{MgSO}_4$  that comprises magnesium cations  $\text{Mg}^{2+}$  (20.19% by mass) and sulphate ions in solution  $\text{SO}_4^{2-}$ . It's a crystalline white material that's soluble in water but not in ethanol. Sulphate-induced hot corrosion is caused by magnesium sulphate. Sulphur is liberated from the molten salt and diffuses into the metal substrate, generating discrete grey/blue coloured aluminium or chromium sulphides.



**Fig 2.1(h):** Magnesium sulphate

## Alkaline azides

Alkaline iodide-azide (SS Distributors, Bangalore) reagent is used to compensate for the presence of nitrates in wastewater samples that may interfere with the oxidation process. Sulfuric acid is used to acidify the solution and dissolve the precipitate. To adjust for the presence of nitrates in wastewater samples that might interfere with the oxidation process, alkaline iodide-azide reagent is added. The precipitate is dissolved when sulfuric acid is added to the solution to acidify it.



**Fig 2.1(i):** Alkaline azide



## Starch

When tri-iodide is present, starch (Karnataka Fine Chemicals, Bangalore) is typically used as a redox titration indicator. The periodic synthesis and consumption of triiodide intermediate in the Briggs-Rauscher oscillation reaction were seen using a starch solution as an indicator. The starch, on the other hand, alters the kinetics of the triiodide ion reaction steps. A standard concentration for a starch indicator is 0.3 percent weight-per-weight. When titrating for dissolved oxygen, starch is used to identify the endpoint (typically a colour change). When triiodide is present in redox titrations, starch is frequently utilised as an indicator. With triiodide, which is formed by combining iodine with iodide, starch forms an extremely dark blue-black complex (often from potassium iodide). If only iodine or solely iodide ( $I^-$ ) is present, however, the complex does not form.



**Fig 2.1(j):** Starch

## 2.2 Equipment's used

### Burette

A burette is a graded glass tube with a tap on one end that is used to dispense known volumes of liquid, particularly in titration method. It's a graded glass tube with a stopcock at one end and a tapering capillary tube at the other. The stopcock valve regulates how much liquid flows from the tube to the burette tip. The volumetric burette and the piston burette are the two most common burette kinds.



**Fig 2.2(a):** Burette



## Pipette

A pipette is a laboratory tool used to convey a measured volume of liquid, and is frequently used in chemistry lab. From single-piece glass pipettes to more complicated customisable or electrical pipettes, pipettes are available in a variety of designs for diverse uses with different levels of accuracy and precision. Many pipettes function by building a vacuum pressure just above liquid-holding container and then selectively delivering that vacuum to pull liquid up and out. The precision of measurements varies substantially based on the equipment. Piston-driven air displacement powers these pipettes.



**Fig 2.2(b):** Pipette

## Laboratory Tripod

A laboratory tripod is a three-legged structure that holds flasks and beakers in place. Tripods are most often composed of stainless steel or aluminium and are designed to be compact for easy transport inside the laboratory. To provide a flat basis for glassware, a wire gauze is commonly put on top of the tripod. A Bunsen burner may usually be put below a tripod that is tall enough. For basic heating experiments in middle and high schools, a laboratory tripod is most typically utilized. Hot plates, on the other hand, have rendered tripods and Bunsen burners useless, as they do not come into direct touch with the flame.



**Fig 2.2(c):** Laboratory Tripod stand

## Weighing balance

A weighing balance is a device that measures the weight or mass of an item. They're useful in laboratories since they come in a variety of sizes and weighing capabilities. A weighing scale is a device for measuring weight, Balances measure the mass of an object and are used in science, In many industrial and commercial applications, scales and balances to determine the weight and/or mass of things ranging from feathers to loaded tractor-trailers. The basis of the rapid and exact working method of our Weigh Cells is the Principle of Electro Magnetic Force Restoration (EMFR). The basic principle is comparable to a simple beam balance. The weight is laid on one side of the beam (coil arm). The result is that the coil attached to the other side of the beam tries to move out of the magnetic field of the magnet.



**Fig 2.2(d):** Weighing balance

## Remi stirrer

The majority of the equipment is made up of the body, chuck, stainless steel blade propeller, and stand.

It has a function that,

- 1) High torque even at low speeds,
- 2) Controlling the stirring speed with precision,
- 3) Keeping track of the specified and real speeds,
- 4) Even when the load or voltage changes, the speed remains constant,
- 5) Torque and speed are displayed on the screen and
- 6) Controlling the pace of stirring with precision



**Fig 2.2(e):** Remi stirrer

## **Vernier calipers**

A vernier calipers is what it sounds like a linear measuring device is a device that is used to measure linear dimensions. It may also be used to measure the diameters of circular objects using the measuring jaws. A vernier scale is a visual tool for getting an accurate measurement reading between two graduation lines on a linear scale, boosting resolution and minimizing measurement uncertainty by applying vernier acuity to reduce human guessing error. The vernier constant is also known as the least count of vernier calipers.



**Fig 2.2(f): vernier caliper**

## Laboratory Funnel

Laboratory funnels are funnels designed specifically for use in a chemical lab. There are several types of funnels that have been modified for these particular uses. A funnel is a tube or pipe with a broad aperture at the top and a tiny opening at the bottom that is used to funnel liquid or powder into a small hole. To transport liquids or fine-grained materials into containers having a narrow mouth. Used to flow liquids or powder through a tiny aperture and to keep filter paper in place during filtering. In tiny containers, it's used to transport liquids. In poultry husbandry, killing cones are funnels that are used to murder individual birds. The funnel is used to suspend a bird upside down in order to bleed it more readily.



**Fig 2.2(g):** Laboratory funnels

## Measuring cylinder

A Measuring cylinder, also known as a Graduated cylinder, is a piece of laboratory apparatus that is commonly used to measure the volume of a liquid. It has a cylindrical form that is thin. Each marked line on the graduated cylinder reflects the volume of liquid measured. Graduated cylinders are frequently used to determine the amount of a liquid. Graduated cylinders are normally more exact and precise than laboratory flasks and beakers, but they should not be used for volumetric analysis; rather, volumetric glassware, such as a volumetric flask or volumetric pipette, should be used, as it is even more accurate and precise. Graduated cylinders can be used to estimate the volume of a solid by monitoring the displacement of a liquid.

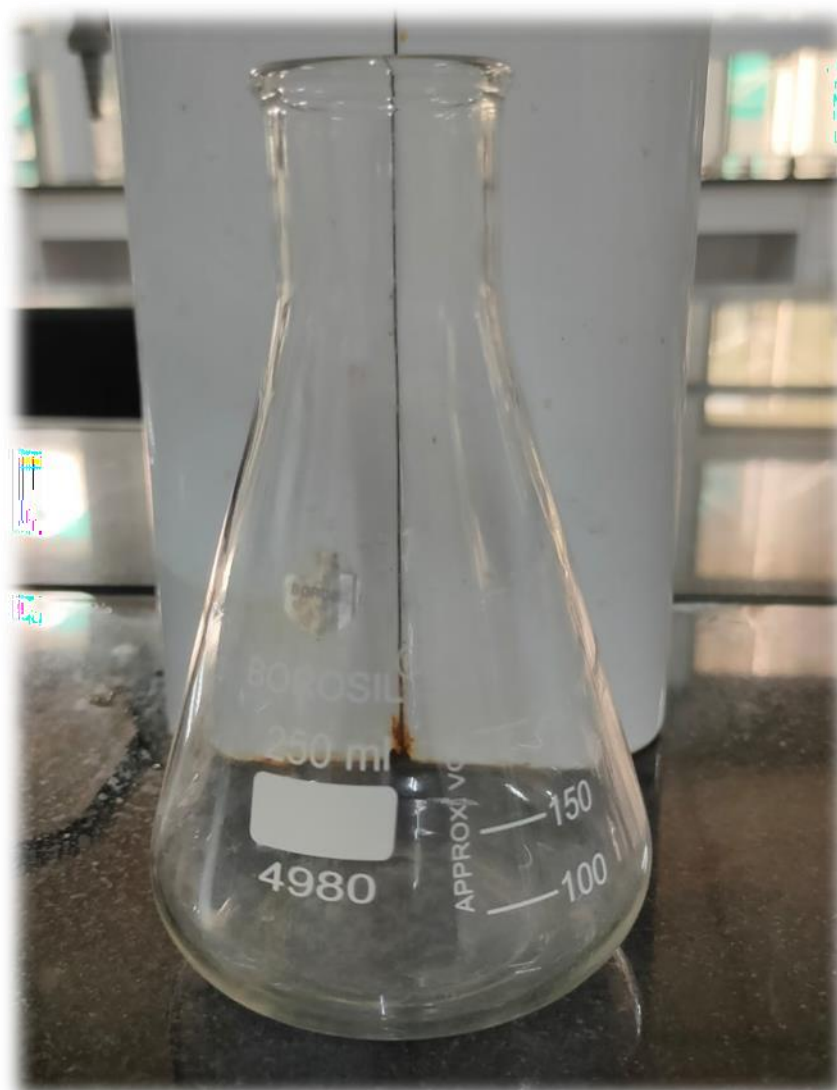


**Fig 2.2(h):** Measuring cylinder



## Conical flask

A conical flask, also known as an Erlenmeyer flask, is a glass jar used in chemical laboratories that has a large flat bottom and a thin cylindrical neck. They're commonly used to combine liquids. The glass flask's large base and thin neck make it ideal for whirling liquids or other substances together. The flask's contents remain contained and do not leak. Although a round-bottomed flask is preferred, the contents can instead be heated on a stove. Plastic Erlenmeyer flasks can be used in laboratories by microbiologists to develop microbial cultures. With proper airflow, its distinctive form encourages and improves development.



**Fig 2.2(i):** Conical flask or Erlenmeyer flask



## Hot air oven

Hot air ovens are disinfected with dry heat. Pasteur was the one who came up with the idea. A thermostat is mainly used to regulate the temperature. Their double-walled insulation keeps the heat in and saves energy since the inner layer is a poor conductor and the outer layer is metallic. A hot air oven is a scientific tool that sterilizes laboratory equipment and other materials by using dry heat. A hot air oven has a temperature range of 50 to 300 degrees Celsius. A temperature regulator can be used to regulate it.



**Fig 2.2(j):** Hot air oven

## pH meter

A pH meter, which is an electronic device, is used to determine the activity of hydrogen ions in a solution (acidity or alkalinity). A pH meter consists of a voltmeter, a pH sensitive electrode, and a comparison (unvarying) electrode. A pH meter is a scientific device that measures hydrogen-ion activity to detect the acidity or alkalinity of water-based solutions. The pH meter is sometimes known as a "potentiometric pH meter" because it monitors the difference in electrical potential between a pH electrode and a reference electrode. The difference in electrical potential determines the solution's acidity or pH. From laboratory testing to quality control, the pH meter is used in a number of applications.



**Fig2.2(k):** pH meter

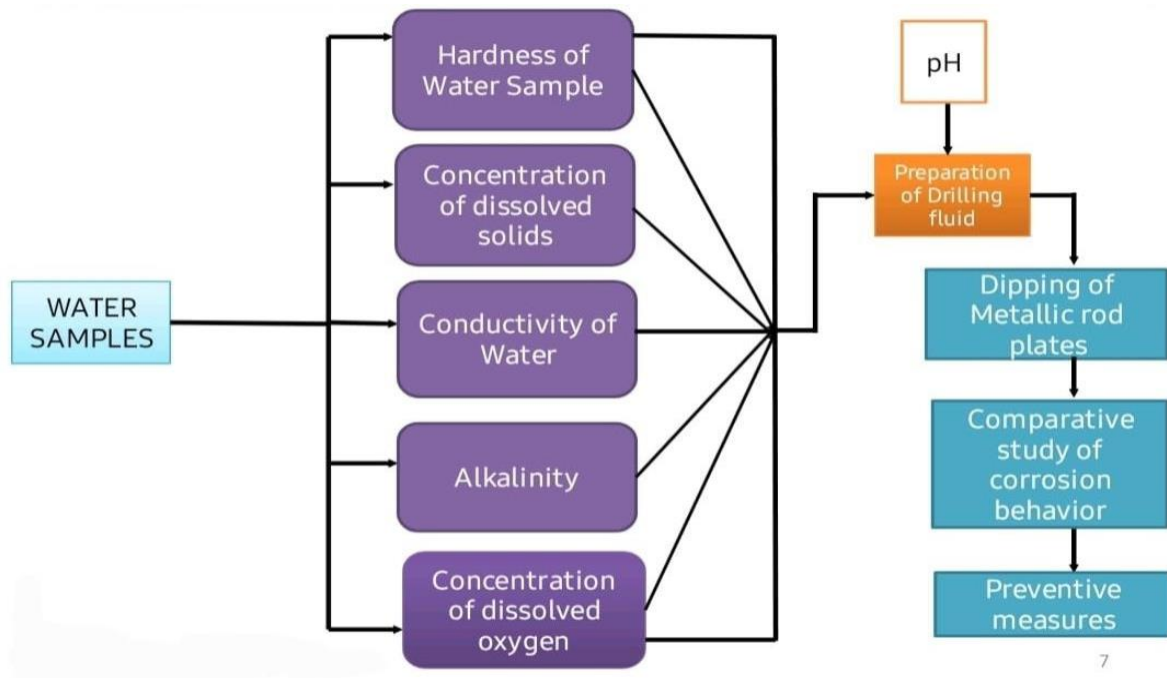
## Electrical conductivity meter

The conductivity meter is used to determine the electric conductivity of a solution. It is regularly used to decide the amount of nutrients, salts, or contaminants in water, aquaculture, aquaponics, and freshwater bodies. A conductivity meter can be used to check the electric conductance of a solution. One or extra probes are typically covered with this device, that is typically small and portable. The conductivity is measured the use of sensors at the probes' ends. The readings from those probes are proven on a display via way of means of an instrument. When you turn at the instrument, it grants a voltage to the electrodes, which reasons a present day to float thru the fabric you are measuring. The device can compute voltage and present day the use of Ohm's regulation and voltage and present-day parameters.



**Fig2.2(l):** Conductivity meter

## 2.3 FLOW CHART



**Figure 2.3: Flow Chart**

- 1) In this project, first we will be collecting different water samples from different Sources.
- 2) After collecting the samples, we will be characterizing those water samples by testing its Hardness, Concentration Total of dissolved solids [TDS], Conductivity, Alkalinity, Concentration of dissolved oxygen.
- 3) After conducting these experiments, we will prepare drilling fluids using Bentonite, Barite, Potassium Chloride, Sodium Hydroxide, Calcium Carbonate, Starch with different water samples and also check the pH of each drilling fluid.
- 4) Our setup will be made up of glass with six compartments of dimension (35×10) cm. In these six compartments we will pour Drilling fluid samples and dip the metallic rods slowly into the drilling fluid and with the help of metallic plate on the top to keep it steady.
- 5) These rods will be kept under observation
- 6) Frequently corrosion on these metallic rods will be measured
- 7) Will report the results and finally a conclusion will be made.

# **CHAPTER 3**

## **EXPERIMENTATION**

## **Chapter 3: Experimentation**

### **3.1 Determination of Hardness of Water**

Hardness of water is affected by the presence of dissolved calcium and magnesium. It is unsuitable for drinking, swimming, or washing, and it also produces scales in boilers. As a result, the amount of hardness generating chemicals contained in the water sample must be estimated. Once approximated, the amount of chemicals necessary for water treatment may be computed. The hardness is estimated via complexometric titration. A standard solution of ethylene diamine tetra acetic acid (EDTA), a complexing agent, is used to measure the hardness of water. As EDTA is insoluble, this method employs the disodium salt of EDTA. EDTA may establish four or six coordination connections with a metal atom.

#### **3.1.1 Apparatus**

- a) Water sample,
- b) Burette 25-30ml,
- c) Glass funnel,
- d) Pipette 1ml,
- e) Flask,
- f) Dropper,
- g) Measuring cylinder,
- h) Burette and
- i) Erlenmeyer flask

#### **3.1.2 Reagents**

- a) EDTA,
- b) Eriochrome Black-T,
- c)  $\text{NH}_2\text{Cl}$ ,
- d) Ammonia Buffer,
- e) Magnesium,
- f) Carbonate and

g) Distilled water.

### **3.1.3 Reagent preparation:**

- 1) EDTA solution: mix 4 grammes of EDTA and 0.1 grammes of magnesium bicarbonate in 800 milliliters of distilled water.
- 2) 0.4g Eriochrome Black T, 4.5g hydroxylamine hydrochloride, 100ml 95 percent ethyl alcohol.
- 3) Ammonia Buffer is a term that refers to a substance that is used to Stock A: 16.9 gramme  $\text{NH}_4\text{Cl}$  in 143 ml conc.  $\text{NH}_4\text{OH}$ , Stock B: 1.25 gm magnesium salt of EDTA in 50 ml distilled water.
- 4) Mix the two stock solutions together and dilute with DDW to 250mL. With DDW, dilute 10ml of the solution to 100ml.

### **3.1.4 Procedure**

- 1) To the zero level, the burette is filled with normal EDTA solution.
- 2) Fill a flask with 50ml of water. If the sample contains a lot of calcium, dilute it to 50ml using a smaller amount.
- 3) 1ml Ammonia buffer should be added.
- 4) Using the Eriochrome Black – T indicator, add 5 to 6 drops. The solution takes on the colour of wine.
- 5) Take note of the first reading.
- 6) Test the content with an EDTA solution. At the end, the colour changes from wine red to blue.
- 7) Take note of the final reading and write it down. Repeat the process until we receive a value that is concordant.
- 8) Boil a 50ml sample in a different flask. (Add distilled water to reach the final volume of water.)

### 3.1.5 Observation



**Fig.3.1.5(a):** Initial point of Hardness of water



**Fig.3.1.5(b):** End point of Hardness of water



## **3.2 Determination of Total Dissolved Solids**

Materials that are totally dissolved in water are referred to as total dissolved solids. In nature, these solids can be filtered. It's defined as the residue left behind after a filterable sample has been evaporated. Total suspended solids are components that are not dissolved in water and are not filterable in nature. It's described as the residue left behind after a non-filterable material has evaporated on filter paper.

### **3.2.1 Principle**

A well-mixed sample is filtered through a conventional glass fibre filter, then evaporated to dryness in a weighted dish and dried at 179-181°C to a consistent weight. The total dissolved solids are represented by the increase in dish weight. The residue remaining on the filter is dried to a consistent weight at 103-105°C after a well-mixed sample is filtered through a weighted standard glass fibre filter. The total suspended particles are represented by the filter's increased weight. The difference between the total solids and total dissolved solids may offer an estimate of total suspended solids if the suspended material clogs the filter and causes filtering to take longer.

### **3.2.2 Apparatus**

- a) Evaporating Dish
- b) Water Bath
- c) Oven
- d) Desiccators
- e) Analytical Balance
- f) Graduated Cylinders
- g) Dish Tongs
- h) Gooch Crucibles
- i) Filter
- j) Crucible tongs
- k) Forceps, Smooth -tipped

### **3.2.3 Sample Handling and Preservation**

- 1) It is not possible to preserve the sample.
- 2) Since biological activity continues after a sample is obtained, changes in the sample may occur while processing and storage.
- 3) The quantity of solids as well as their features may alter.
- 4) Keep all samples obtained for solids assays at 40 C to minimize this change.
- 5) Samples should not be allowed to freeze.
- 6) As soon as it is possible, research should be proceeded.

### **3.2.4 Precautions**

The following precautions should be observed while performing the experiment:

- 1) Water or wastewater samples containing high amounts of calcium, chloride, magnesium, or sulphate can effectively absorb moisture from the air.
- 2) To attain a decent consistent weight, such samples may need to be dried for a longer amount of time, chilled under adequate desiccation, and weighed quickly.
- 3) We should be aware that drying over an extended period of time might result in the loss of components, notably nitrates and chlorides.
- 4) The volume of the sample should be adjusted so that there is 100 to 200mg of residue remaining after drying.
- 5) The purpose is to keep a considerable amount of residue from entrapping water during evaporation.
- 6) To guarantee that all of the bicarbonate is converted to carbonate, further drying at 180C is required for samples with high quantities of bicarbonate.

### **3.2.5 Testing of sample for Total Suspended Solids**

- 1) In a filter flask, place the filtration device with the weighted filter.
- 2) Mix the sample thoroughly and pour it into a graduated cylinder to the desired volume.
- 3) Apply suction to the filter flask and fill with distilled water to seat the filter.

- 4) Fill the filtering equipment to the desired capacity. Into the filter flask, draw the sample through the filter.
- 5) Using three 10mL volumes of distilled water, rinse the graduated cylinder into the filtering equipment, allowing complete drainage between each washing.
- 6) Continue suctioning for three minutes after the last rinse has been filtered.
- 7) Dry the filter for at least 1 hour in a 103-105°C oven.
- 8) Cool the desiccator filter to room temperature. When the filter is cool, weigh it and support it.



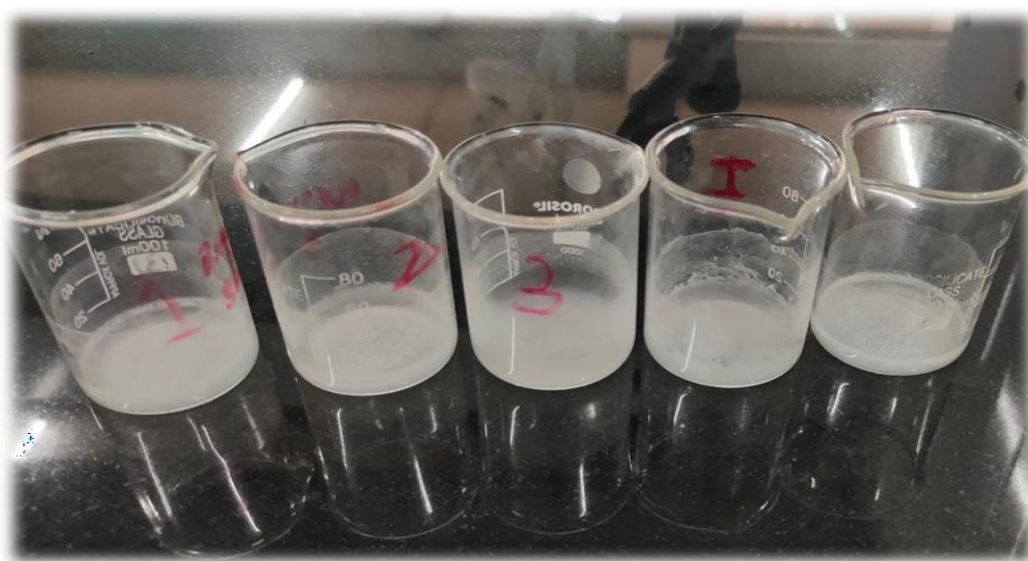
**Fig 3.2.5:** Testing of sample for Total Suspended Solids

### **3.2.6 Testing of sample for Total Dissolved Solids**

- 1) Take a clean porcelain dish that has been cleaned and dried in a hot air oven at 180°C for one hour to calculate total dissolved solids.
- 2) In a weighing balance, weigh the empty evaporating dish.
- 3) Let's call the weight that was measured  $W_1$ .
- 4) Mix the sample thoroughly before pouring it into a funnel lined with filter paper.

- 5) Filter around 80-100 mL of the sample.
- 6) Transfer 75mL of unfiltered sample into the porcelain dish with a pipette.
- 7) Turn on the oven and set the temperature to 105°C.
- 8) To reach the required range of temperature, monitor and modify oven as well as furnace temperatures on a regular basis.
- 9) To acquire a consistent mass, dry the sample.
- 10) Drying for a long time, generally 1 to 2 hours, eliminates the need to check for continuous mass.
- 11) In a desiccator, cool the container. Desiccators are intended to provide an uniform dry atmosphere.
- 12) The desiccant inside keeps this from happening.
- 13) The desiccant inside keeps this from happening.
- 14) Maintain a lubricated desiccator lid to seal the desiccator and prevent moisture from entering when the test glassware cools.
- 15) Because of its hygroscopic nature, we should weigh the dish as soon as it has cooled to minimize moisture absorption.
- 16) Samples must be correctly measured, weighed, and totally dried and chilled.
- 17)  $W_2$  denotes the weight with residue.

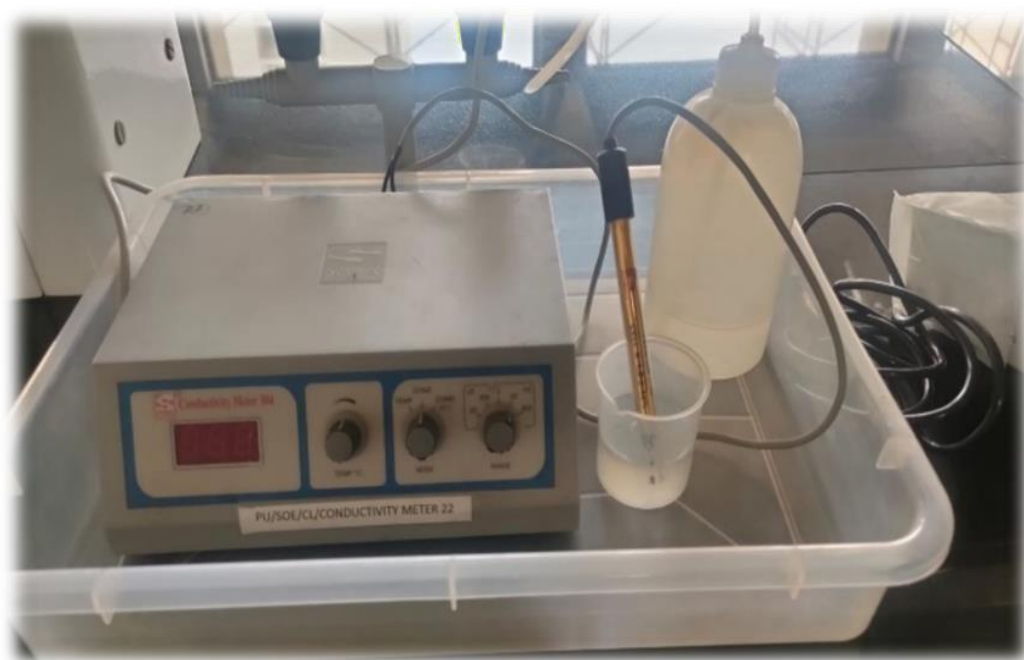
### 3.2.7 Observation



**Fig 3.2.7:** Physical observation of Total Dissolved Solids

### 3.3 Determination of Conductivity of water

The capacity or capability of a substance to transfer or transmit heat, electricity, or sound is defined as conductivity. When an electrical potential difference is applied across a conductor, the conductor's moveable charges flow, causing an electric current to flow. Conductivity is the name for this attribute. The conductivity of a solution is related to its ion concentration because the charge on ions in solution aids the conductance of electrical current. Mhos (Reciprocal of ohms) and siemens are two ways to measure electrical conductivity. The capacity of water to convey an electric current is measured by its conductivity. Because the conductivity of most water is relatively low, water conductivity is measured in milli-siemens or micro-siemens. The concentration of ions and their mobility are closely related to the conductivity of water. Water ions serve as electrolytes, conducting electricity. The conductivity of water is determined by the pH value, the measuring temperature, and the quantity of  $\text{CO}_2$  dissolved in the water to produce ions. The concentration of ions already existing in the water, such as chloride, sodium, and ammonium, has an impact on conductivity. The conductivity of water is determined by its chemical makeup. As a result, this will be the most extensively used indicator of water cleanliness.



**Fig.3.3** Digital Conductivity Meter

### **3.3.1 Principle**

With a probe and a meter, conductivity is measured. In the probe submerged in the sample water, a voltage is applied between the two electrodes. The conductivity per centimetre is calculated using the decrease in voltage generated by the resistance of the water. Ohm's law is used to calculate conductivity (G), the inverse of resistivity (R), using voltage and current quantities. In other words, if  $R=V/I$ , then  $G=1/R=I/V$ . The meter translates the probe data to micro mhos per cm and shows the user the outcome.

### **3.3.2 Apparatus required**

- a) Conductivity Meter with Electrode /ATC probe,
- b) Magnetic Stirrer with stirring bead,
- c) Standard flask,
- d) Measuring jar,
- e) Beaker 250 mL,
- f) Funnel and
- g) Tissue Paper.

### **3.3.3 SAMPLE HANDLING AND PRESERVATION**

Plastic cans or glass bottles should be used to collect water samples. All bottles must be properly cleaned with a phosphate-free detergent and washed with both tap and distilled water. The amount of material gathered should be enough to ensure a representative sample, allow for repeat analysis (if necessary), and reduce the amount of waste. After the collection, the research should commence as early as feasible. If the research cannot be finished within 12 hours of the sample being collected, the sample should be filtered using 0.45 filter paper and kept at 4°C. Washing the filter and equipment with high-quality distilled water is required, and the filter and equipment must be rinsed with sample before use. There is no need for chemical preservation. Maintain a temperature of 4°C for the samples. Samples should not be allowed to freeze.

### **3.3.4 Precautions**

The following precautions should be observed while performing the experiment:

- 1) Before beginning the experiment, turn on the conductivity meter for minimum 30 minutes to allow the equipment to settle.
- 2) Because it requires analyzing instruments, don't forget to calibrate them.
- 3) Always make the calibrating solution from scratch before starting the experiments.
- 4) Because temperature affects conductance, always use a conductivity meter with controlling the temperature.
- 5) Usually keep the electrode submerged in pure water as well as avoid exposing it to the air.

### **3.3.5 Procedure**

The reagents must be produced beforehand in order to test the provided water sample. After that, the conductivity metre must be calibrated.

#### **3.3.5.1 PREPARATION OF REAGENTS**

##### **Potassium Chloride Solution (0.1N):**

- 1) Turn on the analytical balance, keep the weighing pan in place, and zero the value.
- 2) 50 mL pure water, measured and transferred to the beaker Potassium chloride weighs 0.7456 grammes.
- 3) Add the 0.7456g of potassium chloride to the distilled water beaker and stir with the glass rod until completely dissolved.
- 4) Fill the 100 mL regular flask halfway with the components.
- 5) Using distilled water, increase the amount to 100 mL and thoroughly shake the components.
- 6) The conductivity meter is calibrated using this solution.

### **An overview on conductivity meter:**

The conductivity of a solution is measured using an electrical conductivity metre.

The conductivity unit is made up of the following components:

- a) Conductivity Meter
- b) Electrode ATC probe
- c) Magnetic stirrer with bead

Power on the equipment for at least 30 minutes before beginning the experiment to ensure that it is stable. The Conductivity metre can measure three parameters using the same electrode.

- a) Conductivity
- b) Salinity
- c) Total Dissolved Solids (TDS)

Automatic temperature control (ATC) probe can also be used to show the temperature of the room. The parameter to be monitored is selected by pressing the Mode button. The monitor may show micro-siemens or milli-siemens conductivity readings. Because temperature has a significant impact on the conductivity of a solution, it is vital to calibrate the equipment at the same temperature as the solution being analysed.

### **3.3.6 TESTING OF WATER SAMPLE**

1. Using deionized water, thoroughly wash the electrode and wipe it dry with a clean napkin.
2. Take 200 mL of water to a beaker and set it on the magnetic stirrer.
3. Pause for a stable reading after dipping the electrode into the test solution in a beaker. Check to see if the equipment is giving you a consistent value.
4. Take a straight note of the reading in the display, which is given in milli siemens.



### 3.4 Determination of Alkalinity

Natural fluids can be alkaline or acidic, although pure water is neutral. Most natural waters have a pH between 4 and 9. The bulk of water samples are somewhat basic owing to the existence of alkali and alkaline earth metal carbonates as well as bicarbonates. Borates, silicates, and phosphates are occasionally found as alkalinity producers.

The tendency of water to neutralize chemicals can be characterized as alkalinity. The sum of all alkaline species observed in a sample water contributes to the alkalinity of the sample water. However, for the purpose of simplicity, the alkalinity of water samples is measured in milligrams of calcium carbonate per cubic meter.

These are:

- a) Hydroxides only alkalinity
- b) Carbonates only alkalinity
- c) Bicarbonates only alkalinity
- d) Hydroxides and carbonates alkalinity
- e) Carbonates and bicarbonates alkalinity

It is essential to assess the nature and extent of alkalinity present in the water sample to ascertain its suitability for different applications.

1. In this experiment you would learn about the principle of the determination of total alkalinity of a water sample based on acid base titration and also perform such a determination.
2. This method of titration will help you in understanding the basic principle of some important industrial analyses such as that of :
  - a) soda ash,
  - b) sodium bicarbonate,
  - c) mixture of sodium carbonate and sodium bicarbonate,
  - d) commercial caustic soda,

- e) washing soda, etc.

### **3.4.1 Objectives**

After studying and performing this experiment you should be able to:

- 1) State and explain the principle of acid-base titration with special reference to the determination of alkalinity of a water sample,
- 2) Prepare a standard solution of sodium carbonate,
- 3) Standardize the given solution of hydrochloric acid and use it in determining the alkalinity of water sample, and
- 4) Determine the hydroxide only, carbonate only and hydroxide and carbonate only alkalinity in the given water sample.

### **3.4.2 Apparatus**

- a) Volumetric flasks (100 cm<sup>3</sup>)
- b) Burette (50 cm<sup>3</sup>)
- c) Pipettes (10 cm<sup>3</sup>)
- d) Weighing bottle
- e) Burette stands with clamp
- f) Conical flask
- g) Funnel

### **3.4.3 Chemicals used**

- a) Hydrochloric acid
- b) Sodium carbonate
- c) Ethyl alcohol
- d) Phenolphthalein
- e) Methyl orange
- f) Water sample

### 3.4.4 SOLUTIONS PROVIDED

- A. **Phenolphthalein indicator solution:** It's made by dissolving 1 g of reagent in 100 cm<sup>3</sup> ethanol and then adding 100 cm<sup>3</sup> water. A precipitate is filtered if it forms.
- B. **Methyl orange indicator solution:** It's made by dissolving 0.5 grams of the indicator's free acid form in 100 cm<sup>3</sup> of water.
- C. **Hydrochloric acid solution (~0.1 M):** It's made by gently adding 10 cm<sup>3</sup> of concentrated HCl to around 100 cm<sup>3</sup> of distilled water in a 1 dm<sup>3</sup> volumetric flask, then diluting the acid to the desired strength using distilled water.

### 3.4.5 PROCEDURE

The processes for determining the alkalinity of a water sample using the double indicator technique are as follows:

- 1) Establishing a sodium carbonate standard solution 38.
- 2) Titrating against a standard sodium carbonate solution to standardize hydrochloric acid solution.
- 3) Titrating hydrochloric acid solution against a standard sodium carbonate solution to standardize it.
- 4) Titrating against standardized hydrochloric acid to determine the Phenolphthalein end point.
- 5) Titrating Phenolphthalein against standardized hydrochloric acid to determine the end point.
- 6) By titrating over standardized hydrochloric acid, the methyl orange endpoint was determined.
- 7) Hydroxide and carbonate ion concentrations are calculated.
- 8) To measure the alkalinity of a particular water sample, use the step-by-step process shown below.

### 3.4.6 Observation



**Fig 3.4.6(a):** Initial point of Alkalinity of water



**Fig.3.4.6(b):** End point of Alkalinity of water

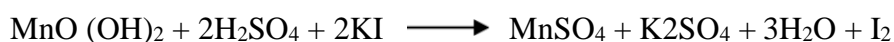
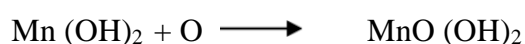
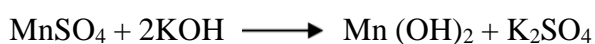
### 3.5 Determination of Concentration of dissolved Oxygen

The levels of dissolved oxygen (DO) in ambient water are affected by the physiochemical as well as biochemical processes in the water body, and it is an essential tool for pollution and waste treatment process management.

The following are two popular methods for determining DO concentration:

- (1) The iodometric technique, which is a titration-based approach that relies on the oxidizing property of DO, and
- (2) the membrane electrode process, which relies on the rate of molecular oxygen diffusion over a membrane.

In a glass-stopper container, divalent manganese solution is introduced to the solution, followed by strong alkali. DO quickly oxidize an equal quantity of distributed divalent manganese hydroxide precipitates to higher valence state hydroxides. When oxidized manganese is exposed to iodide ions in an acidic solution, it reverts to a divalent form, releasing the iodine equivalent of the initial DO concentration. The iodine is subsequently titrated using a stranded thiosulfate solution. A starch indicator can be used to determine the titration end point visually.



#### 3.5.1 Apparatus

- a) Burette
- b) Pipette
- c) Conical Flask
- d) Beakers
- e) Measuring Cylinder

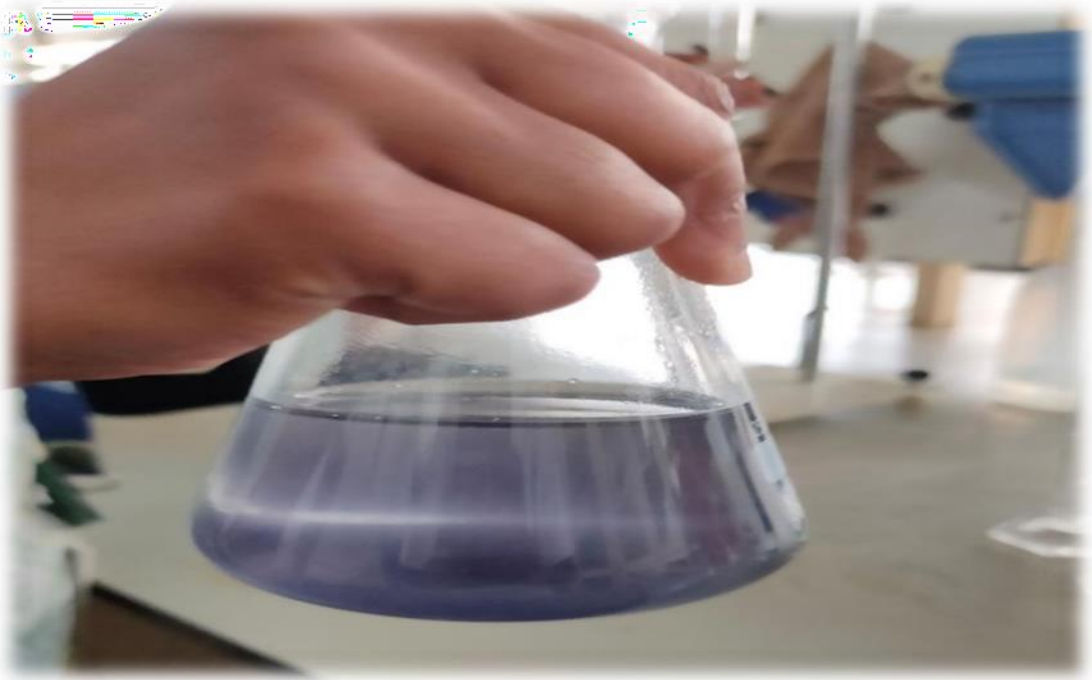
### 3.5.2 Reagents

- 1) **Manganese sulfate solution:** Filter and dilute to 1L using 480 g  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ , 400 g  $\text{MnSO}_4 \cdot 2\text{H}_2\text{O}$ , or 364 g  $\text{MnSO}_4 \cdot \text{H}_2\text{O}$  mixed is deionized water. When  $\text{MnSO}_4$  is introduced to an acidified potassium iodide (KI) solution, it should not produce a colour with starch.
- 2) **Alkali-iodide-azide reagent.**
- 3) **Sulfuric acid:** A mL of alkali-iodide-azide reagent is comparable to around 3 mL.
- 4) **Starch solution:** In 100 mL of deionized water, dissolve 0.2 g salicylic acid as a preserve as well as 2 g of lab-grade soluble starch.
- 5) **Standard sodium thiosulfate titrant:** 6.205 g  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  dissolved in deionized water; add 0.4 g solid NaOH and dilute to 1000 ml or 1.5 mL 6N NaOH. Using a bi-iodate solution, you may achieve consistency.
- 6) **Standard potassium bi-iodate solution (0.0021M):** Using deionized water, dilute to 1000 mL and dissolve 812.4 mg  $\text{KH}(\text{IO}_3)$

### 3.5.3 Procedure

- 1) By using 200mL glass container, collect the sample of water without any bubbling.
- 2) By using the tip of a pipette, add 2 ml of magnesium sulphate ( $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ ) solution to the sample since the droplets of solution can permit oxygen to enter the solution.
- 3) By Using the above- mentioned procedure, add 2 ml of the alkali-iodide-azide reagent. Allowing the solutions to interact with the oxygen in the sample is advisable.
- 4) Whenever the precipitate got settled down at the bottom, add 2 ml of concentrated  $\text{H}_2\text{SO}_4$  to the surface of the sample with the pipette tip held very close to the surface of the sample.
- 5) Take 50 ml of the sample and place it in a flask.
- 6) Using a starch indicator, titrate with sodium thiosulfate solution till the blue colour fades, then record the burette reading.

### 3.5. Observation



**Fig.3.5.3(a):** Initial point of Dissolved Oxygen content of water



**Fig.3.5.3(a):** Final point of Dissolved Oxygen content of water

### 3.6 Composition of Drilling Fluids

Sr No.	Volume of Water Sample	Bentonite (mg/2000 mL)	Barite (mg/2000 mL)	KCL (mg/2000 mL)	NaOH (mg/2000 mL)	CaCO <sub>3</sub> (mg/2000 mL)	Starch (mg/2000 mL)
1	2000ml	120	40	20	20	20	60
2	2000ml	120	40	20	20	20	60
3	2000ml	120	40	20	20	20	60
4	2000ml	120	40	20	20	20	60
5	2000ml	120	40	20	20	20	60
6	2000ml	120	40	20	20	20	60

**Table 3.6:** Composition of Drilling Fluids





**Fig 3.6(a):** Industrial Bentonite Mud



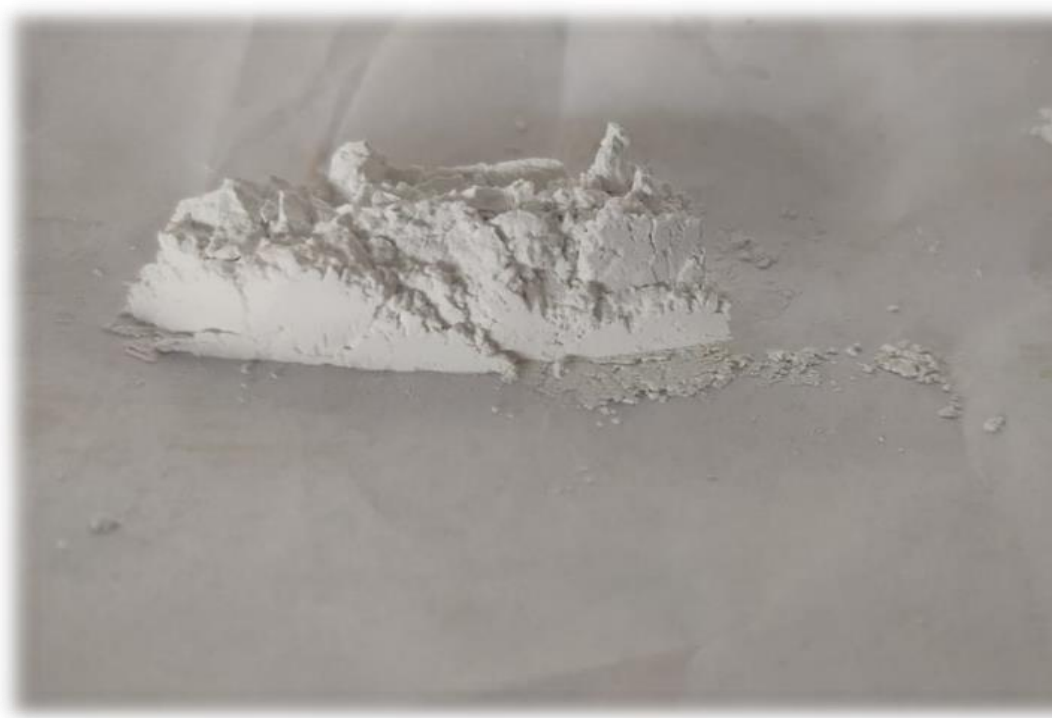
**Fig 3.6(b):** Barite



**Fig 3.6(c):** Potassium chloride – KCl



**Fig 3.6(d):** Sodium hydroxide – NaOH



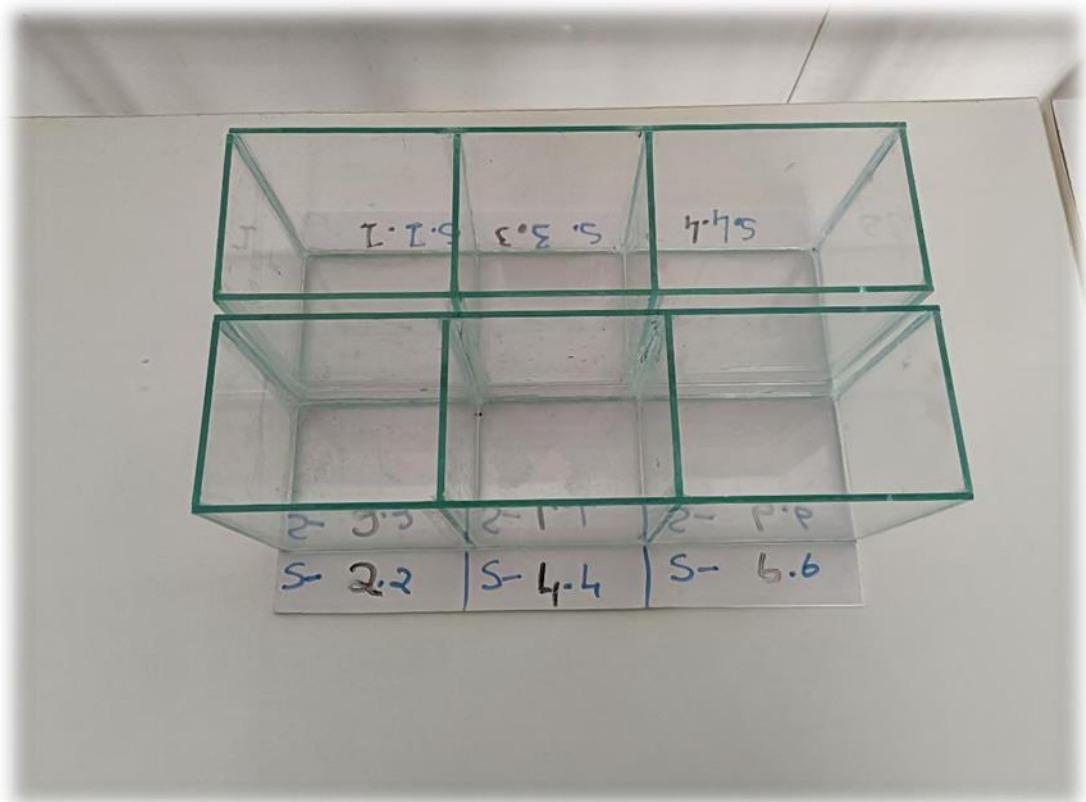
**Fig 3.6(e):** Calcium carbonate –  $\text{CaCO}_3$



**Fig 3.6(f):** Starch

### 3.7 Spadework of Glass Chamber

- 1) The glass chamber is entirely constructed with glass and has six sections with a total length of (3510) cm.
- 2) We'll pour drilling fluid samples into these 6 compartments and gently dip the metallic rods into the drilling fluid, keeping it stable with the assistance of a metallic plate on top.
- 3) These rods will be monitored as well as corrosion on these metallic rods will be recorded on a regular basis.



**Fig 3.7:** Glass Clamber

# **CHAPTER 4**

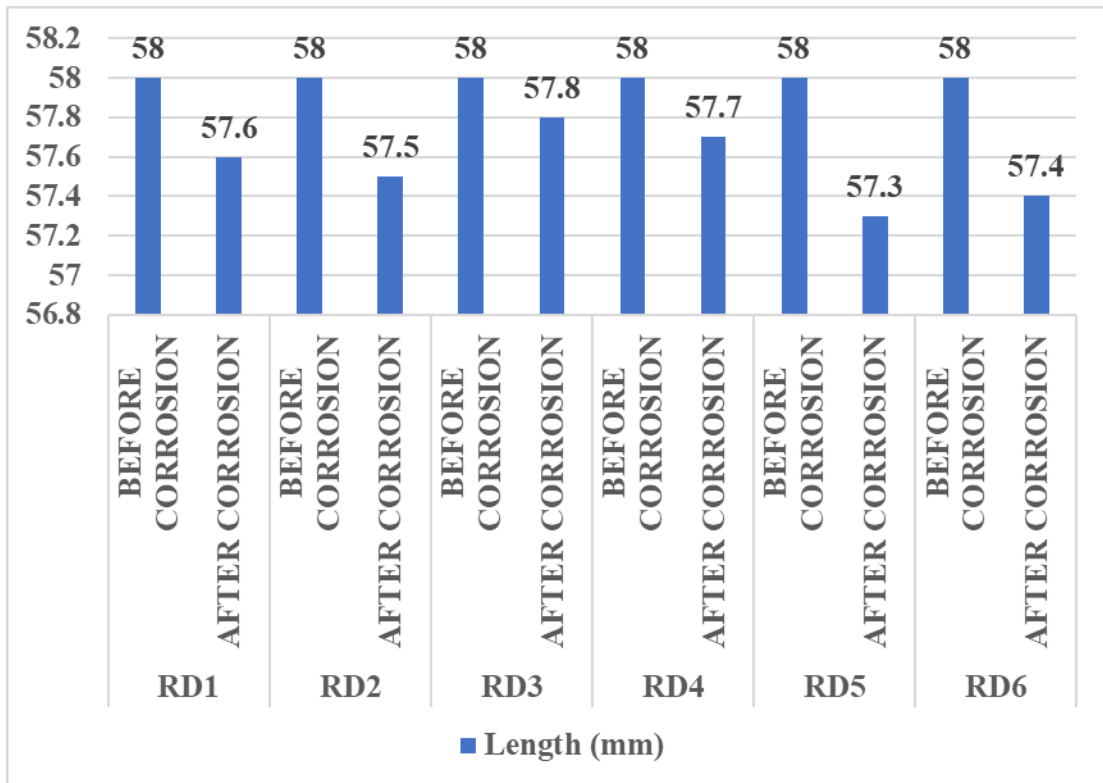
## **RESULTS AND DISCUSSION**

## Chapter 4: Results and Discussion

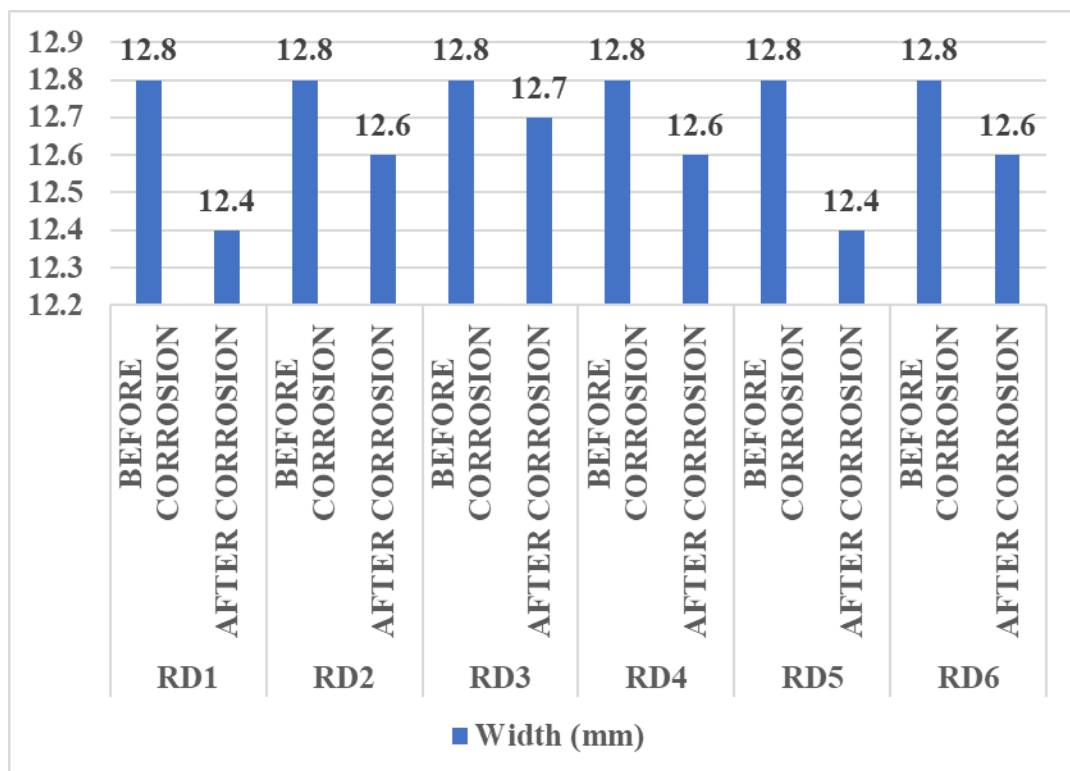
### 4.1 Observation of different parameters before and after corrosion of different sample rods.

SAMPLE ROD	Status	Length (mm)	Width (mm)	Thickness (mm)	Weight (gm)
ROD - 1	BEFORE CORROSION	58	12.8	4.5	50.6
	AFTER CORROSION	57.6	12.4	4.2	50.3
ROD - 2	BEFORE CORROSION	58	12.8	4.5	49.6
	AFTER CORROSION	57.5	12.6	4.2	49.3
ROD - 3	BEFORE CORROSION	58	12.8	4.5	49.4
	AFTER CORROSION	57.8	12.7	4.4	49.2
ROD - 4	BEFORE CORROSION	58	12.8	4.5	49.6
	AFTER CORROSION	57.7	12.6	4.4	49.4
ROD - 5	BEFORE CORROSION	58	12.8	4.5	50.3
	AFTER CORROSION	57.3	12.4	4.2	50
ROD - 6	BEFORE CORROSION	58	12.8	4.5	49.5
	AFTER CORROSION	57.4	12.6	4.4	49.3

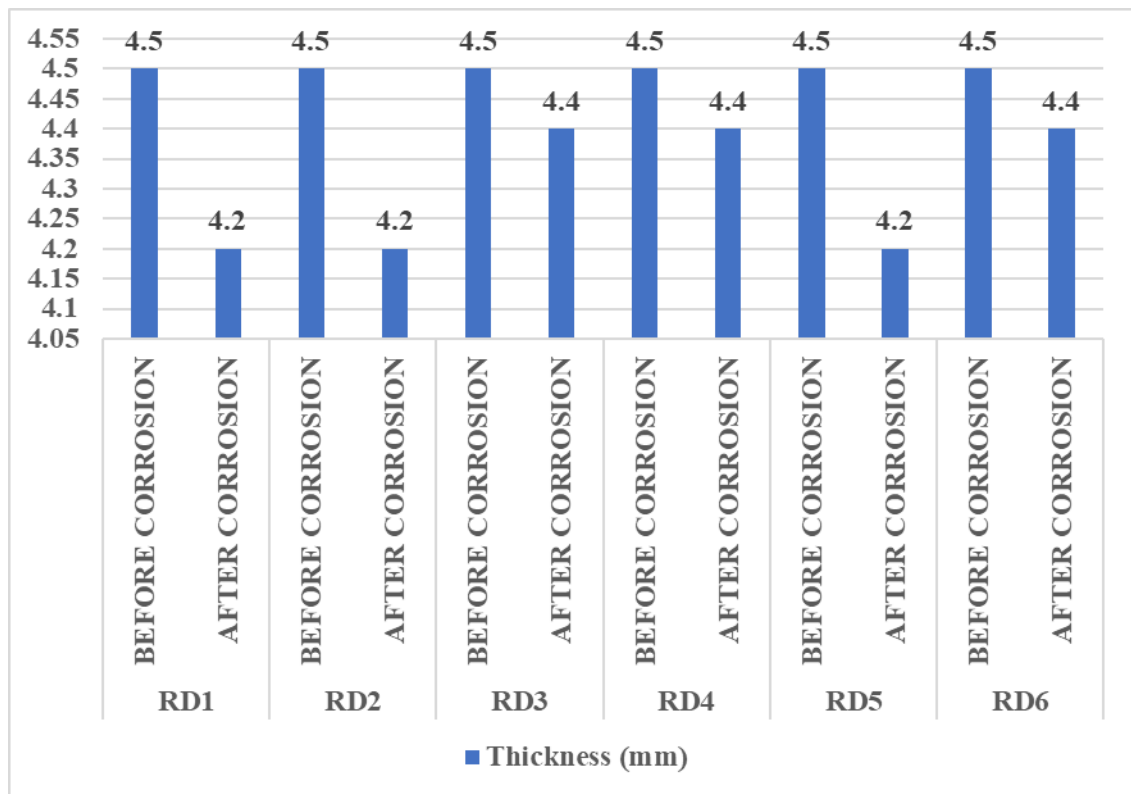
**Table 4.1:** Different parameters before and after corrosion of different sample rods measured by Vernier Callipers.



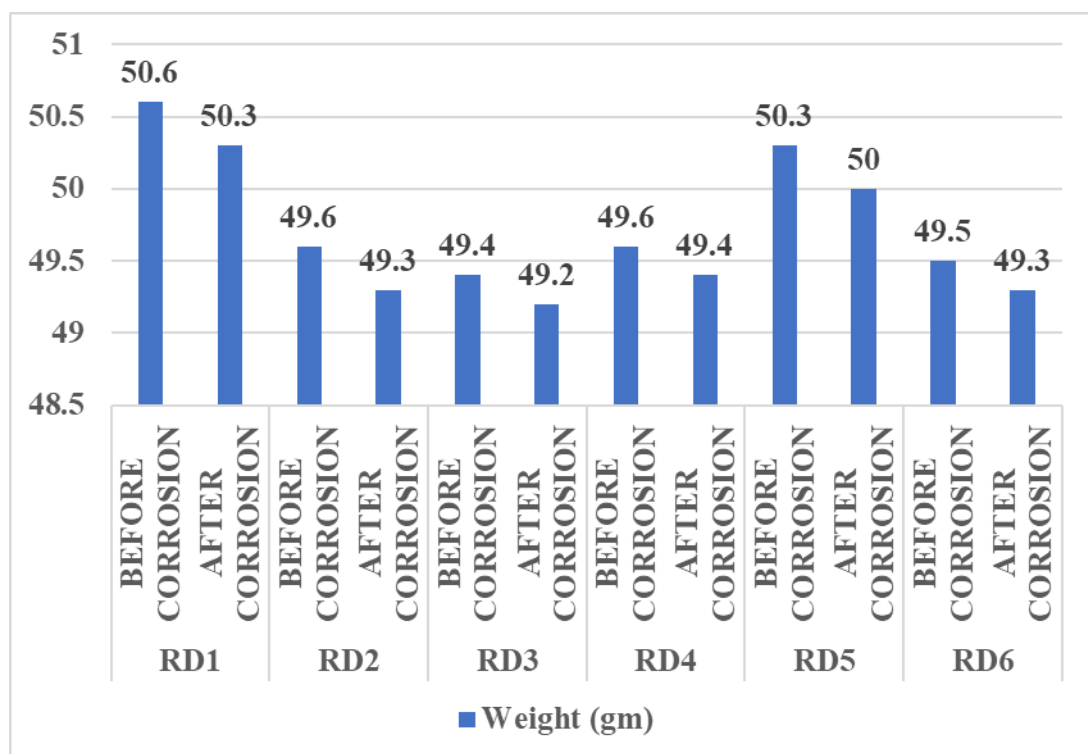
**Fig 4.1(a):** Comparison of length before and after corrosion



**Fig 4.1(b):** Comparison of width before and after corrosion.



**Fig 4.1(c):** Comparison of thickness before and after corrosion



**Fig 4.1.(d):** Comparison of weight before and after corrosion





**Fig 4.1(e): Sample Rods Before Corrosion**



**Fig 4.1(f): Sample Rods After Corrosion**

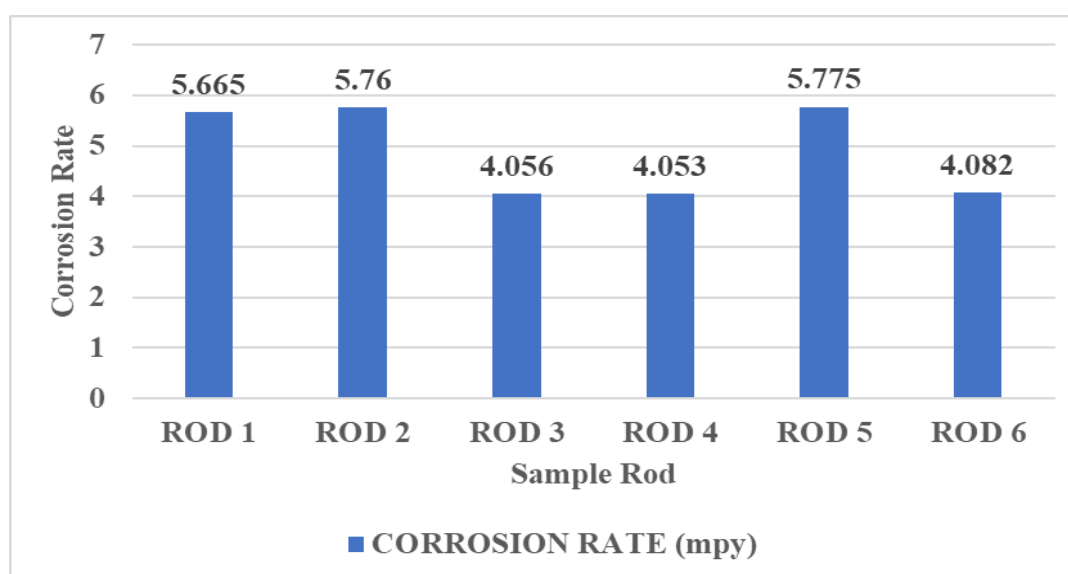
## 4.2 Observation and resulting the corrosion rate for different factors affecting the corrosion

### Corrosion rate for different sample rods

The corrosion rate for several sample rods was measured as well as calculated and the results are listed in Table 4.2 below.

SAMPLE ROD	CORROSION RATE (mpy)
ROD 1	5.665
ROD 2	5.76
ROD 3	4.056
ROD 4	4.053
ROD 5	5.775
ROD 6	4.082

**Table 4.2:** Corrosion Rate of different sample rods.



**Fig 4.2:** Comparison of Corrosion Rate for different sample rods.

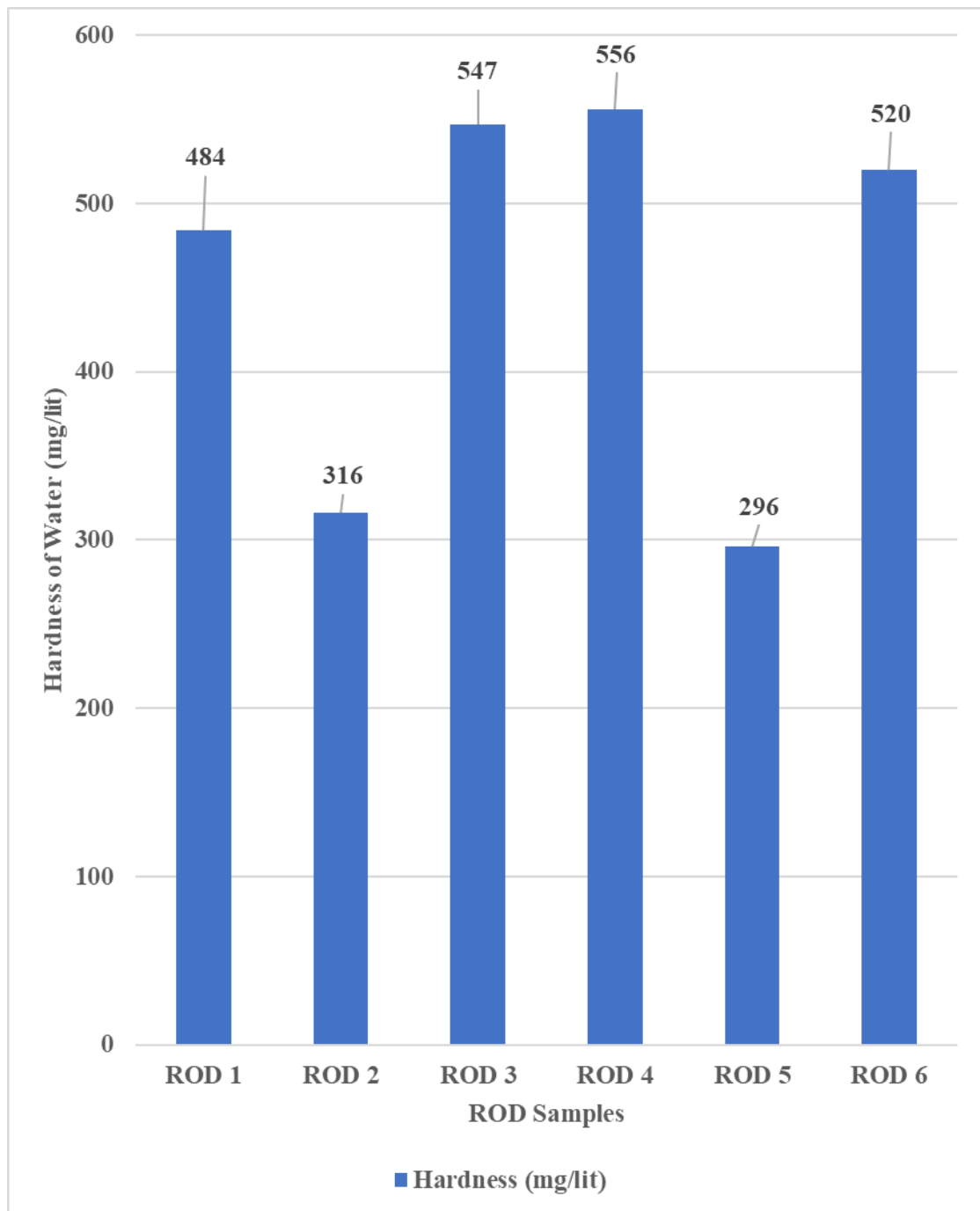
### 4.3 Hardness of water

The combination of soluble bicarbonates, chlorides, and calcium and magnesium sulphates causes hardness of water. Water that does not lather with soap is considered hard water. Titration with an EDTA solution is the most frequent technique used to determine the hardness of water. The A titration is done by slowly adding tiny volumes of a solution to a sample water until the sample changes colour. You can use a burette to titrate a sample to determine the overall hardness of water.

Water hardness affects plumbing materials in different ways depending on mineral content, temperature, and pH. The most well-known issues related with hard-water mineral deposits include poor efficiency and functional life of plumbing equipment subjected to hot hard water. Acidic water promotes corrosion, reducing the life of plumbing components and causing fixture stains and discoloration. Furthermore, the efficiency of most compounds, including the reagents, disinfectants, and pharmaceuticals, is reliant on the pH of the water. Because of all these factors, most aquatic facilities choose fairly hard water with a steady pH (+0.6). If a facility's municipal water source is soft water, numerous features of the piping systems should be seriously analysed.

<b>CORROSION RATE (mpy)</b>	<b>Hardness (mg/lit)</b>
<b>5.665</b>	<b>316</b>
<b>5.76</b>	<b>484</b>
<b>4.056</b>	<b>520</b>
<b>4.053</b>	<b>556</b>
<b>5.775</b>	<b>296</b>
<b>4.082</b>	<b>547</b>

**Table 4.3** Corrosion Rate with respect to Hardness of water



**Fig 4.3** Comparison of Corrosion Rate with respect to Hardness of water

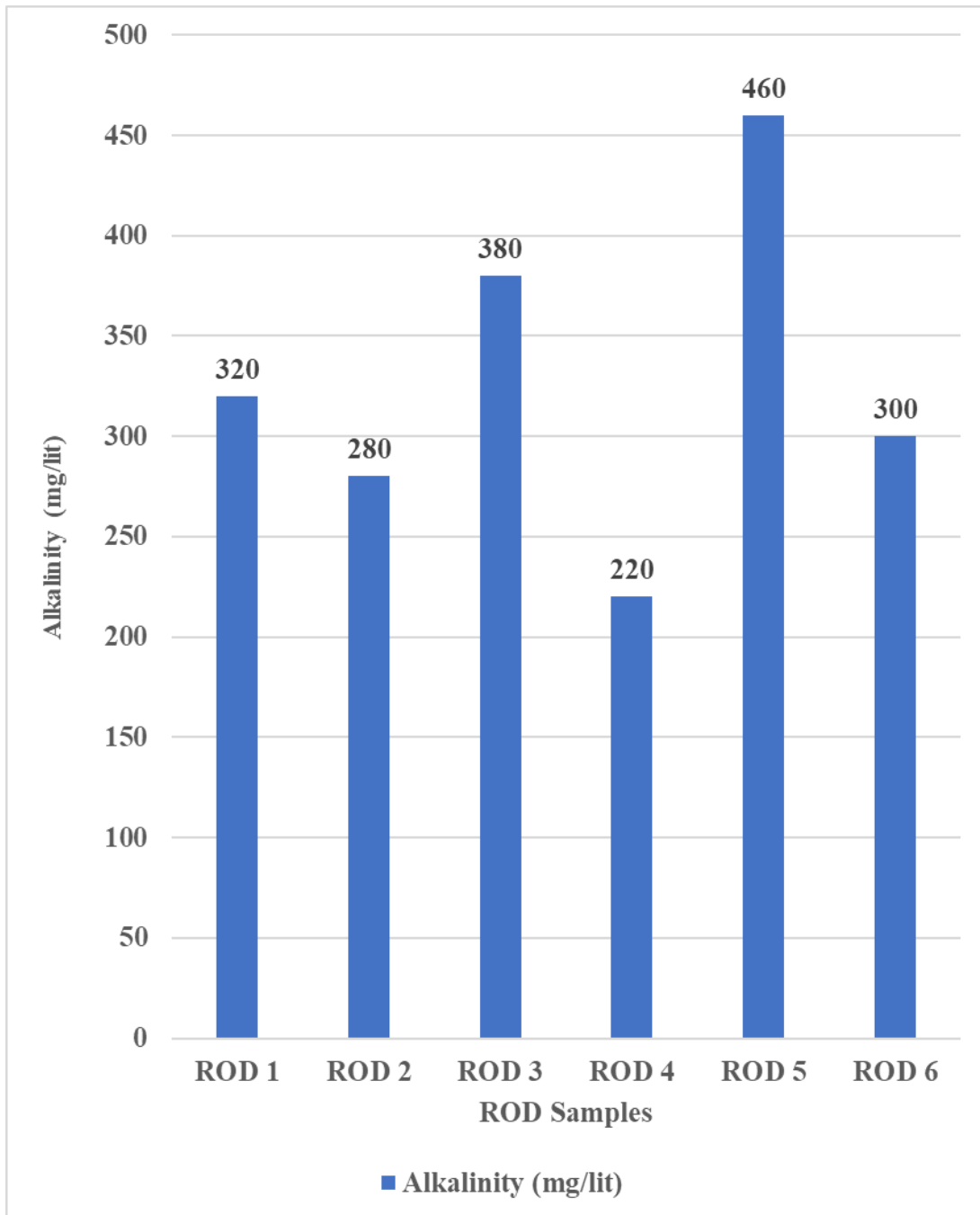
- a) According to Fig 4.3, when the hardness increases, the rate of corrosion reduces
- b) Hard water is less corrosive because the minerals which actually produce hard water cover and protect the interior of pipes.
- c) Because soft water includes sodium ions, it doesn't cover the pipes and is hence extremely corrosive.

#### 4.4 Alkalinity of water

The capacity of a buffer solution made up of weak acids and their conjugate bases is known as alkalinity. The ability of water to withstand acidification is known as alkalinity. The buffering capacity of a water system is therefore defined as "a way of measuring the water bodies natural ability to neutralize compounds and so manage a relatively steady pH level. Alkalinity is a feature of water quality that is influenced by the presence of specific compounds in the water, which including chloride ions, fluoride ions, and hydroxide ions. Simply said, water with a high alkalinity likely exhibit little variation in its own acidity when acidic water, such as acid rain or an acid spill, is injected into the water body. It is not to be confused with basicity, and that is a pH scale absolute measurement. The alkalinity of a surface waterbody, including a pond, is often derived from the rocks and ground surrounding the lake.

<b>CORROSION RATE (mpy)</b>	<b>Alkalinity (mg/lit)</b>
<b>5.665</b>	<b>300</b>
<b>5.76</b>	<b>280</b>
<b>4.056</b>	<b>380</b>
<b>4.053</b>	<b>460</b>
<b>5.775</b>	<b>220</b>
<b>4.082</b>	<b>320</b>

**Table 4.4:** Corrosion Rate with respect to Alkalinity of water.



**Fig 4.4:** Comparison of Corrosion Rate with respect to Alkalinity of water

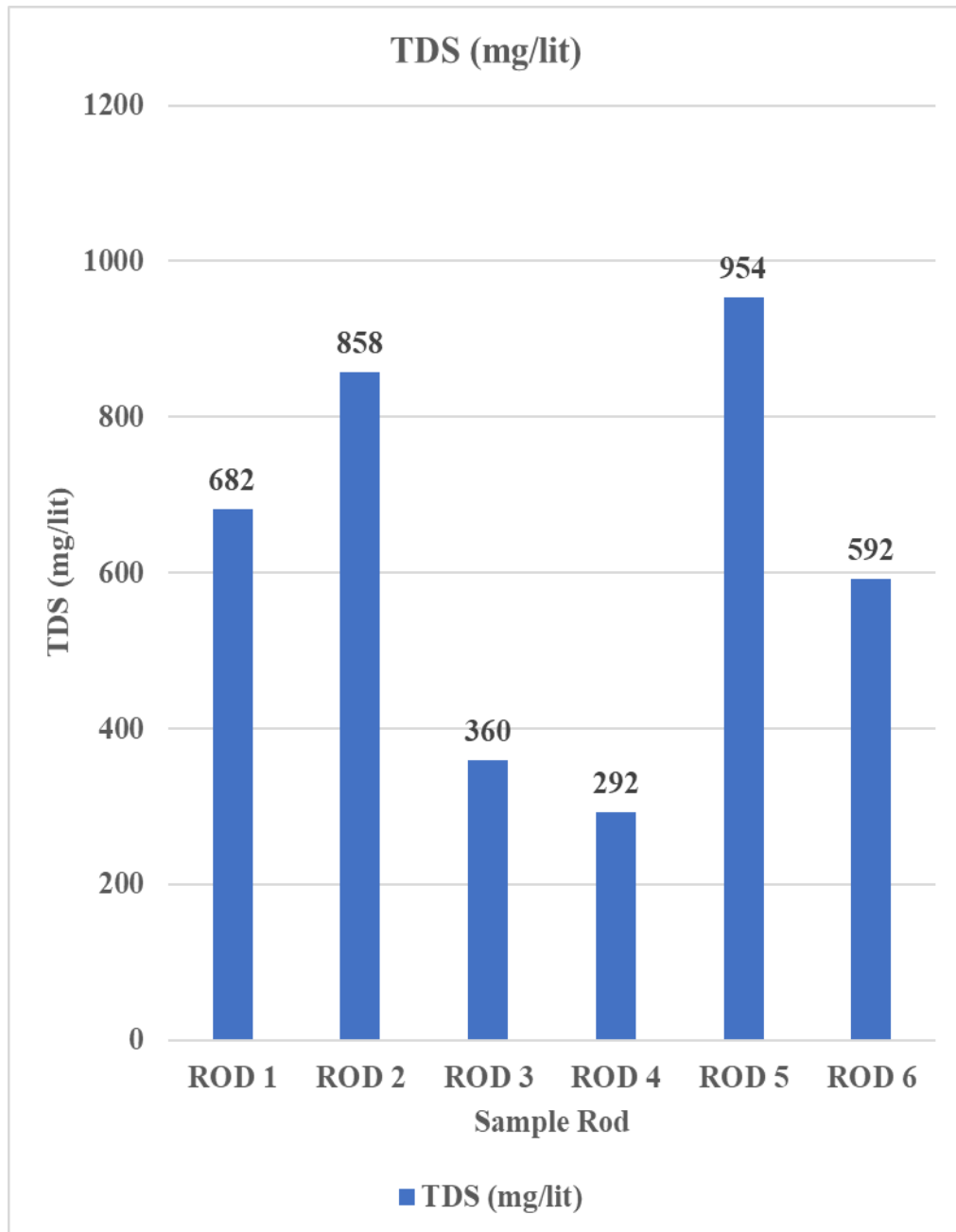
- a) According to Fig. 4.4, when the alkalinity of water increases, the rate of corrosion reduces.
- b) As water alkalinity rises, it becomes more resistant to changes in water pH or, more crucially, it has a higher capacity to modify the pH of something else, such as soils or potting mixes.
- c) It is considerably more likely that the pH will alter.

#### 4.5 Total dissolved solid (TDS)

TDS refers to the Total dissolved solids is a measurement of the molecular, ionized, or micro-granular (colloidal solutions) suspended material of all inorganic and organic compounds present in a solution. Parts per million (ppm) is a common unit of measurement for TDS levels (ppm). TDS contents in water may be measured and recorded by a digital meter. The sum of the cations (positively - charged ions) as well as anions (negatively - charged ions) ions in the solution is known as the total dissolved solids content. As a result, while the TDS method offers a qualitative estimate of the number of dissolved ions, it doesn't reveal the type of the ions or their interactions. Furthermore, the test doesn't reveal particular water quality concerns including hardness, saltiness, stains, fumes, corrosiveness, or the existence of trace metals and microbial pollutants. As a result, the TDS method is employed as an indication test to estimate the overall water quality. TDS can be derived from all dissolved cations and anions. Total dissolved solids can also be used as a quick check to ensure that a full test of specific ions is accurate and complete

<b>CORROSION RATE (mpy)</b>	<b>TDS (mg/lit)</b>
<b>5.665</b>	360
<b>5.76</b>	592
<b>4.056</b>	954
<b>4.053</b>	858
<b>5.775</b>	292
<b>4.082</b>	682

**Table 4.5** Corrosion Rate with respect to Total dissolved solids.



**Fig 4.5** Comparison of Corrosion Rate with respect to Total dissolved solids

- a) According to Fig. 4.5, an increase in total dissolved solid lead to an increase in corrosion rate.
- b) High TDS: Corrosion becomes more likely when TDS levels exceed 500 ppm.
- c) Low pH: The possibility of pitting and corrosion rises when the pH falls below 7.0.
- d) High water temperature: Warm water accelerates chemical processes and releases dissolved CO<sub>2</sub>, both of which lead to corrosion.



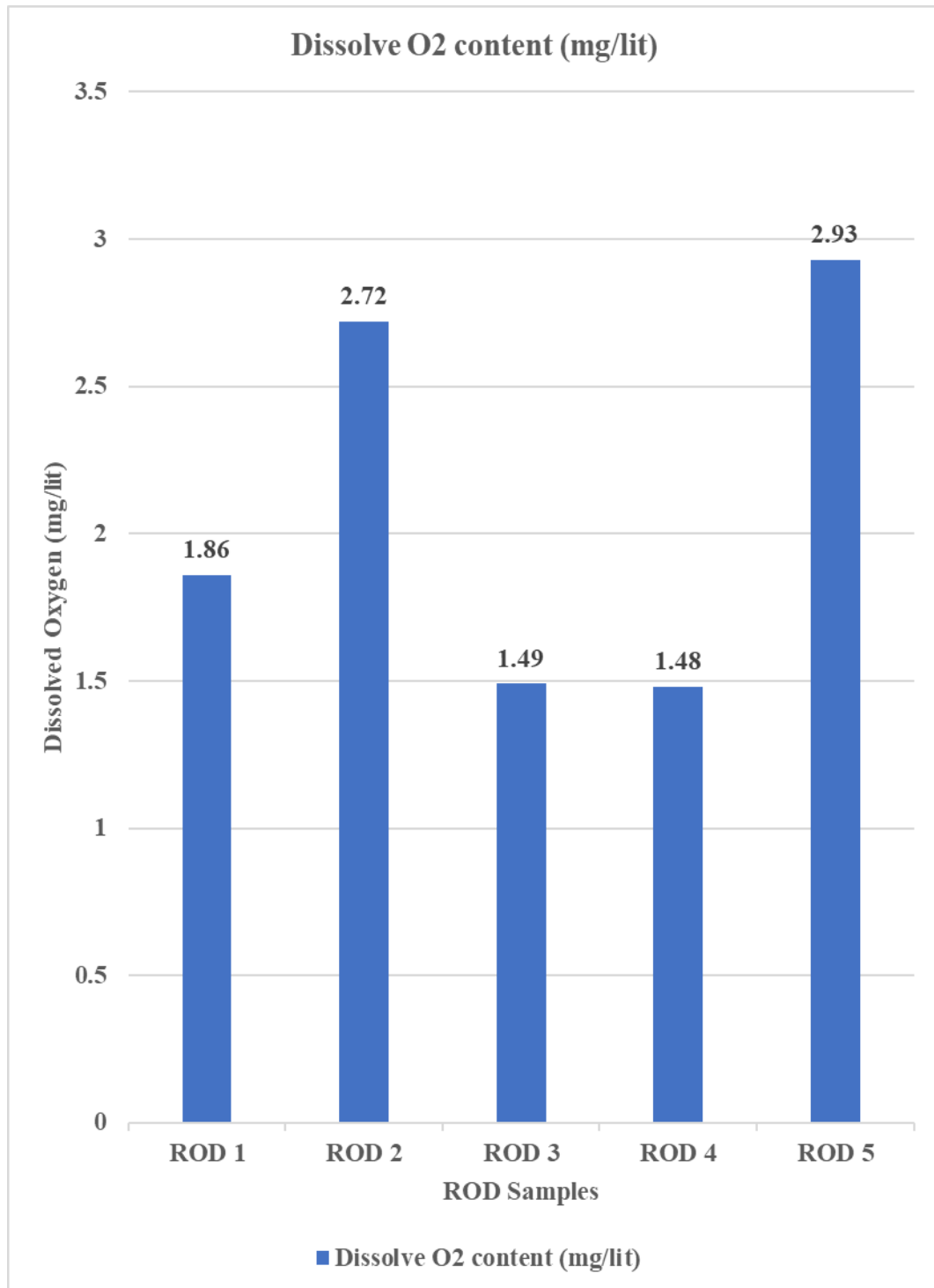
## 4.6 Dissolved Oxygen content

The amount of oxygen contained in water is referred to as dissolved oxygen (DO). The atmosphere and aquatic organisms both supply oxygen to water bodies. Running water, such as that found in a fast-flowing stream, dissolves more oxygen than motionless water in a pond or lake that is stationary. Dissolved oxygen can oxidize dissolved ions into insoluble forms and ruin the shielding hydrogen coating that can develop on many metals. Rust deposits in a plumbing system are an example of differential aeration cells, which speed up corrosion.

The term BOD - Biochemical Oxygen Demand – is used to assess the aerobic fully destructible of organic compounds. The biological approach for measuring the total quantity of dissolved oxygen (DO) consumed by bacteria in the biological system of metabolizing organic compounds present in water is known as BOD. Dissolved oxygen refers to the entire quantity of oxygen gas contained in water (DO).

<b>CORROSION RATE (mpy)</b>	<b>Dissolve O<sub>2</sub> content (mg/lit)</b>
<b>5.665</b>	<b>1.48</b>
<b>5.76</b>	<b>1.86</b>
<b>4.056</b>	<b>2.93</b>
<b>4.053</b>	<b>2.72</b>
<b>5.775</b>	<b>1.75</b>
<b>4.082</b>	<b>1.49</b>

**Table 4.6** Corrosion Rate with respect to Dissolved Oxygen content.



**Fig 4.6** Comparison of Corrosion Rate with respect to Dissolved Oxygen content

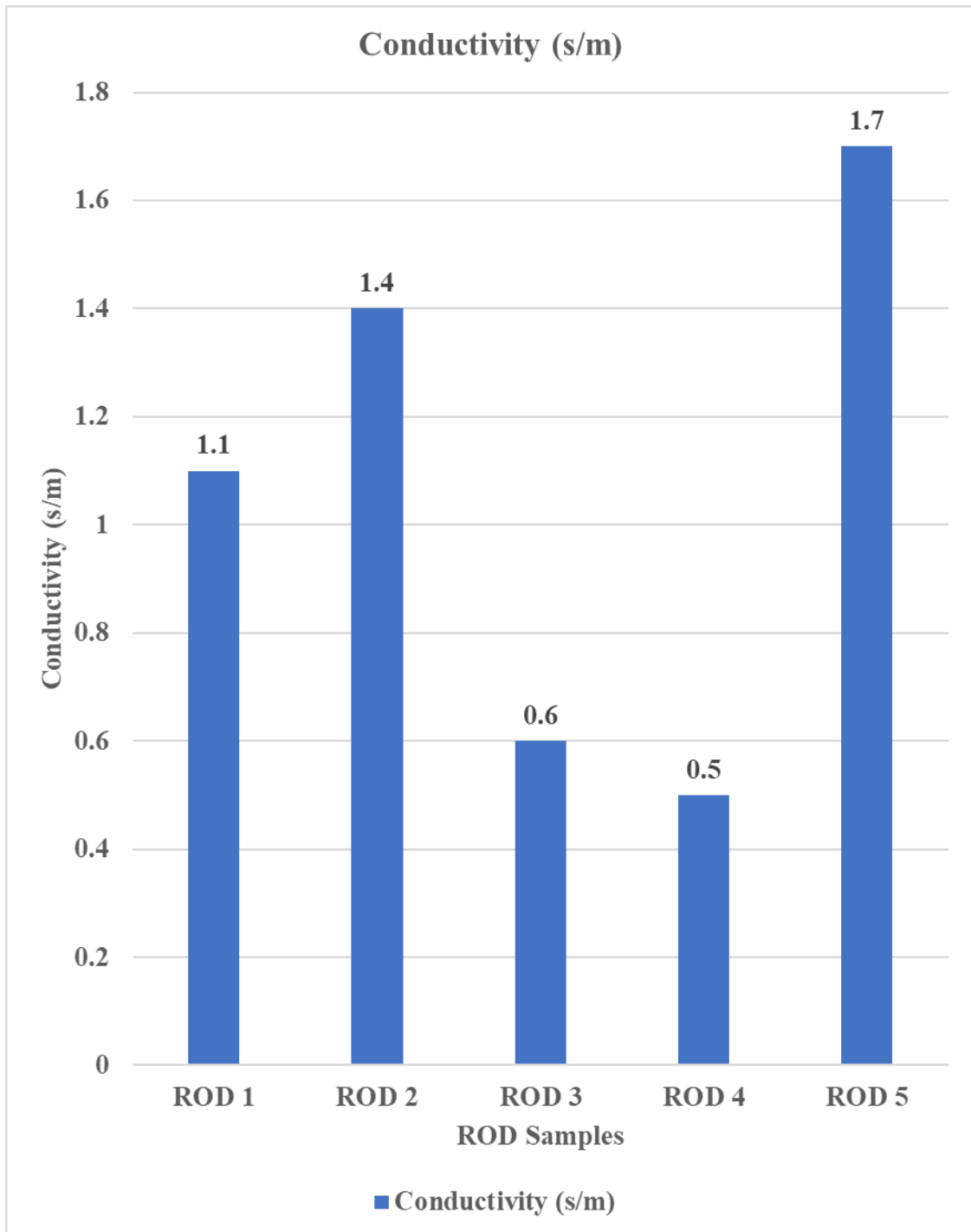
- According to Fig. 4.6, the corrosion rate increases fast with increasing dissolved oxygen level in various corrosion conditions.
- Oil and gas well pipelines will be extensively corroded by even a little quantity of dissolved oxygen.

## 4.7 Conductivity of water

The conductivity of water is a measurement of its capacity to carry electrical current. The number of conductive ions in the water directly influences this capacity. Inorganic elements such as chlorides, alkalis, carbonate and sulphide complexes, and dissolved salts produce these conductive ions. The degree to which water conducts or transmits electricity, heat, or sound is referred to as conductivity of water. Electrolytes are organic compounds that dissolve into ions. The greater the number of ions existing in the electrolyte, the greater the conductivity of water. Likewise, the conductivity of water decreases as the number of ions in the solution decreases. Because of its extremely low conductivity, deionized or distilled water can also behave as an insulator. The conductivity of seawater is believed to be quite high. It is thought that pure water is a poor conductor of electricity. Impurities in the form of ions termed minerals, for example, are considered to be present in regular water. The conduction of electric current in water is known to be caused by these ions.

<b>CORROSION RATE (mpy)</b>	<b>Conductivity (s/m)</b>
<b>5.665</b>	<b>0.9</b>
<b>5.76</b>	<b>1.1</b>
<b>4.056</b>	<b>1.7</b>
<b>4.053</b>	<b>1.4</b>
<b>5.775</b>	<b>0.6</b>
<b>4.082</b>	<b>0.5</b>

**Table 4.7:** Corrosion Rate with respect to Conductivity of water.



**Fig 4.7:** Comparison of Corrosion Rate with respect to Conductivity of water

- According to Fig 4.7 that when conductivity increases, the quantity of Corrosion Rate increased as well.
- While the conductivity meter is not ideal, it can be useful in determining overall corrosion patterns in a solution.

# **CHAPTER 5**

## **PREVENTIVE MEASURES**

## **Chapter 5:      Preventive Measures**

### **5.1 Protective Coatings**

A "protective coating," as the term indicates, is a coating that is put to a surface to protect it from the surrounding atmosphere. "Paints" are commonly used to describe coating that are made for ornamental or aesthetic objectives. Clearly, there is some overlap: the protective coating used around the outside of the steel tank may also be aesthetic, as it improves the tank's look. Likewise, one of it's objectives of the paint you choose for your house's wood trim is to preserve it against degradation. The phrase "coating" will refer to protective coatings and/or coating systems for the purposes of this chapter.

A coating is any relatively thin substance, generally applied as a liquid or powder, that, upon solidification, adheres securely to the covered surface and prevents the environment from touching it. To guard against corrosion for an extended length of time, coatings must be flexible, impact resistant, chemically resistant to the surroundings to which they are exposed, resistant to moisture penetration, have strong adhesion and cohesiveness, and be temperature resistant. Coatings are categorized as "thick film" or "thin film" depending on the thickness of the cured coating layer (dried). Because they are often not single applications of material, protective coatings must be termed to as "coating systems.

A primer coat and a topcoat, or a primer coat, intermediate coat, and topcoat, are the most common types of atmospheric coatings, with each coat serving a distinct role. When the phrases "two coat" or "three coat" are used, they allude to the several types of coatings that were applied to the building, each having its own function. Up to five coatings are possible in certain systems. The adhesive forces that keep the coating to the surface may be stronger than the cohesive forces inside the coating if it is applied too thickly. As a result, the excessively thick covering will start to peel away.

A coating that is too thin, on the other hand, will not offer an adequate barrier and may erode the metal surface. The desired anchor pattern will be determined by the needed coating thickness and surface preparation blasting.

## **5.2 Types of coatings**

### **A. Primers**

All anticorrosion coatings require primer, which is regarded as a critical component of the coating system. Provides a strong bind to the metal substrate (better than other coatings) and a tie (inter-coat bond) to the next coat.

- 1) As a barrier, it may give good corrosion and chemical resistance,
- 2) As a corrosion inhibitor, it could be useful (inhibitive primer) and
- 3) Using a sacrificial metal to defend against corrosion is a possibility (zinc-rich primer).

Prior to shipping, the surfaces of the equipment or facilities may be prepped and a primer layer applied. It might take weeks or months to apply the finishing coat(s). As a result, the primer may need to keep rust from forming in the atmosphere for a long time. Primers are classified into three types: barrier primers, inhibitive primers, and sacrificial primers (or galvanic or cathodic). The linkages to the metal substrate and the following coat are provided by all three kinds.

### **B. Intermediate Coating**

In three or more coat systems, the intermediate coat(s) is also known as the "barrier coat" or "body coat."

- 1) Gives the entire coating thickness,
- 2) Enhances the high level of chemical resistance,
- 3) Prevents moisture vapor transmission. Increases the coating's electrical resistance,
- 4) Ensures a high level of cohesiveness (strength within the coating film),
- 5) It creates a solid link between the primer and the topcoat,
- 6) In several tough situations, the intermediate coat is a vital layer and
- 7) As a result, many offshore installations use three-coat systems.

### **C. Top Coating**

The topcoat, often known as the "final coat," protects the paint from chemicals, water, as well as the environment. Ensures that the coating system is well-sealed.

- 1) It acts as a first line of defense against the outside world,
- 2) Supplies chemical, water, and weather resistance,
- 3) Provides a smooth, touchable, and wear-resistant surface with an appealing look and
- 4) Even though the topcoat performs many of the same tasks as the intermediate coat, the pigment-to-vehicle ratio in the topcoat is comparatively lesser.

The topcoat is frequently a different colour than the intermediate coat, allowing the coater and tester to assess coverage.

### **5.3 Corrosion Inhibitors**

An effective inhibitor programme includes selecting the right inhibitor, applying it using a strategy that ensures the inhibitor has an option to play, and tracking and periodic evaluation to ensure command and "highlight" alterations in circumstances that necessitate therapy adjustment. As a result, inhibitor programs must be tailored to individual wells or systems, as well as their mechanical characteristics and operational practices. Corrosion is slowed by one or more methods. Some corrosion inhibitors work by adsorbing to produce an invisible thin coating (monomolecular film); others generate apparent bulky precipitates that coat the metal and shield it from attack.

Another common mechanism consists of causing the metal to corrode in such a way that a combination of adsorption and corrosion product forms a passive layer. Included in the definition are those substances that, when added to an environment, retard corrosion but do not interact directly with the metal surface. This type of inhibitor causes conditions in the environment to be more favorable for the formation of protective precipitates, or it neutralizes an acidic component in the system. Most inhibitors form some type of film on the protected metal surface. The first layer formed may be strongly bonded, perhaps by an electrical charge exchange analogous to a chemical reaction. Such strong bonding is called "chemisorption." Weaker



physical bonding forces are also involved, especially during deposition of subsequent layers of the film.

## **Inorganic Corrosion Inhibitors**

The inorganic corrosion inhibitors are usually metal salts, which will passivate the surface of a metal that normally would not be passivated in the environment. These are water soluble chemicals that react with the metal surface to produce a layer that has protective qualities. A constant (or fixed) concentration is required; therefore, close control is necessary. Care must be taken with some materials because too high or too low concentration can cause accelerated corrosion.

The inorganic inhibitors fall into two classes: anodic and cathodic

### **Anodic Inhibitors**

As the name indicates, the anodic inhibitors react mainly at the anodic areas-this is where corrosion is taking place-and the film formed is a reaction product that is essentially a corrosion product. The net effect is to slow down or stop the corrosion reaction by eliminating the anodic areas. Anodic inhibitors can be divided into two categories: passivators and no passivators. The passivators inhibit in the absence of oxygen. Examples of anodic passivators include the chromates and the nitrites. At one time, the chromates were the inhibitors of choice in the open cooling water systems in plants; however, because of their toxicity, environmental regulations have almost eliminated their use. The no passivators, conversely, require oxygen to be present for their reaction. A common example would be the polyphosphates. Some sources refer to the anodic inhibitors as "dangerous inhibitors." Insufficient dosage will result in incomplete coverage of the anodic areas. These small bare anodic sites will be coupled to the large cathodic areas. The large cathode/small anode relationship, of course, can lead to greatly accelerated pitting at the anodic sites.

## **Cathodic Inhibitors**

On the other hand, the cathodic inhibitors are active at the cathodic sites and thus reduce the cathode/anode relationship and slow down the corrosion reaction. Examples of the cathodic inhibitors are calcium salts, magnesium salts, and zinc salts. While these may be effective inhibitors in fresh water, most oilfield brines contain dissolved salts or gases that would react and cause the inhibitors to precipitate. For example, zinc salt inhibitors will precipitate as zinc sulphide with hydrogen sulphide, or calcium can be precipitated as calcium sulphate scale by dissolved sulphates.

## **Organic Corrosion Inhibitors**

The most common corrosion inhibitors in use in oilfield systems are the so-called "organic film forming inhibitors." Therefore, unless stated otherwise, the remainder of this chapter will be dealing with the organic inhibitors. These are polar organic materials consisting of molecules that have a charge on each end. The polar molecule is often depicted as if it were a tadpole, with a head and a tail. Because of the charges, these polar organics are surface active and are attracted to and tend to cling to solids. Thus, they can form a protective barrier (film) on a metal surface. The long chain hydrocarbon tail on the inhibitor molecule is oleophilic (i.e., it has an affinity for oil).

The net result in oil systems (or produced water system with traces of oil carryover) is an inhabitation film on the metal surface. In effect, an oil-wet condition has been re-established on the metal surfaces. As discussed in a previous chapter, oil wet surfaces repel water and thus break up the corrosion cell by effectively placing a barrier between the electrolyte and the metal surface.

# **CHAPTER 6**

## **CONCLUSIONS**

## **Chapter 6: Conclusions**

### **6.1 Conclusions**

First we have collected five different water samples from five different places, after collecting water samples we have performed different test on that sample namely Determination of Hardness of water(3.1),Determination of Total Dissolved Solids (3.2),Determination of Conductivity of water(3.3), Determination of Alkalinity (3.4) and Determination of Total Dissolved Oxygen (3.5) based on these tests we have found that the results because of different properties of different water samples we have observed corrosion rate is different for different metal rods.

After doing the test for water samples we have observed that,

1. If the Hardness is more than the corrosion rate is low because of the calcium and magnesium ions are presence in the water.
2. If the Alkalinity is more, then the corrosion rate is low because very low and very high values of alkalinity can cause nuisance problems. Alkalinity values less than 75 milligrams per litre can change pH levels in water and make the water corrosive.
3. If the Conductivity is more than the corrosion rate is more because corrosion is an electrochemical process, any increase in conductivity, in general, increases corrosion activity.
4. If the Dissolved Oxygen content is more, then the corrosion rate is more because Oxygen corrosion is the degradation of metals and the reaction of dissolved ions in the presence of oxygen to form insoluble deposits due to the rapid rate of oxidation.
5. If the Total Dissolved Solids is more, then the corrosion rate is more because high TDS. Over 500 ppm TDS, the potential for corrosion increases. Low pH. As pH goes below 7.0, the potential for pitting and corrosion increases.

## **Preventive Measures:**

There are so many processes, to control the corrosion in the oil and gas fields some of them are coating and inhibitors namely:

### **1. Coatings:**

Protective coatings should be referred to as "coating systems," because they are normally no single coats of material. Atmospheric coatings are usually two-or three-coat systems-a primer coat and a topcoat or a primer coat, intermediate coat, and a topcoat-each having its own purpose. When the terms "two coat" or "three coat" are used, this refers to the different type of coatings with different functions.

#### **A. Primary coating:**

The primer is required for all anticorrosion coatings and is considered to be a most important part of coating systems. Some functions of primary coating are

- I. As a barrier, it may give good corrosion and chemical resistance,
- II. As a corrosion inhibitor, it could be useful (inhibitive primer).

#### **B. Intermediate coating:**

The intermediate coat(s) in three or more coat systems is also called the "barrier coat" or "body coat. Some functions of intermediate coating are

- I. Gives the entire coating thickness,
- II. Enhances the high level of chemical resistance.

#### **C. Top coating:**

The topcoat, sometimes referred to as the "finish coat," is the first line of defence against chemicals, water, and the environment. Some functions of top coating are:

- I. It acts as a first line of defense against the outside world,
- II. Supplies chemical, water, and weather resistance.

## 2. Corrosion Inhibitors

Corrosion inhibition is accomplished by one or more of several mechanisms. Some inhibitors retard corrosion by adsorption to form an invisibly thin film (monomolecular film); others form visible bulky precipitates that coat the metal and protect it from attack. Another common mechanism, consists of causing the metal to corrode in such a way that a combination of adsorption and corrosion product forms a passive layer.

### A. Inorganic Corrosion Inhibitors

The inorganic corrosion inhibitors are usually metal salts, which will passivate the surface of a metal that normally would not be passivated in the environment. These are water soluble chemicals that react with the metal surface to produce a layer that has protective qualities. A constant (or fixed) concentration is required; therefore, close control is necessary.

#### a) Anodic Inhibitors

As the name indicates, the anodic inhibitors react mainly at the anodic areas-this is where corrosion is taking place-and the film formed is a reaction product that is essentially a corrosion product. A common example would be the polyphosphates. Some sources refer to the anodic inhibitors as "dangerous inhibitors. These small bare anodic sites will be coupled to the large cathodic areas. The large cathode/small anode relationship, of course, can lead to greatly accelerated pitting at the anodic sites.

#### b) Cathodic Inhibitors

On the other hand, the cathodic inhibitors are active at the cathodic sites and thus reduce the cathode/anode relationship and slow down the corrosion reaction. While these may be effective inhibitors in fresh water, most oilfield brines contain dissolved salts or gases that would react and cause the inhibitors to precipitate. For example, zinc salt inhibitors will precipitate as zinc sulphide with hydrogen sulphide, or calcium can be precipitated as calcium sulphate scale by dissolved sulphates.

## B. Organic Corrosion Inhibitors

The most common corrosion inhibitors in use in oilfield systems are the so-called "organic film forming inhibitors." Therefore, unless stated otherwise, the remainder of this chapter will be dealing with the organic inhibitors. The net result in oil systems is an inhabitation film on the metal surface. In effect, an oil-wet condition has been re-established on the metal surfaces. As discussed in a previous chapter, oil wet surfaces repel water and thus break up the corrosion cell by effectively placing a barrier between the electrolyte and the metal surface.

## 6.2 Scope of Future Work

Technologies are being developed to limit corrosion to a minimum level. More research is being conducted in various fields for corrosion protection, and there are huge new scopes for further research. By understanding the cause of corrosion and by these protective measures, the rate of corrosion can be kept in an allowable range and in some cases, corrosion can even be stopped.

The main research on corrosion is conducted by governments and industries, resulting in new science and inventions on corrosion protection. For the last two decades, the role of nanotechnology is increasing the invention of technological advances to control corrosion. Protection methods alone do not guarantee corrosion will not arise.

Prevention is an extra layer of protection against corrosion. Prevention allows you to identify conditions that may lead to corrosion and take timely action to address it, and as corrosion prevention becomes more advanced through innovative design and research, the better you will be able to protect your assets and grow your profits. Shawcor recognizes the importance of using the latest technology and knows that protecting the integrity of your operational assets is key to performance.

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