IJCRM
International Journal of Contemporary Research In Multidisciplinary

*Research Article*

# Corrosion: Mechanisms, Types, Effects, And Prevention Techniques

**Naba Kumar Sahu**
Lecturer In Chemistry, R.D.S Degree, M.V., Kundabai, Odisha, India

**Corresponding Author:** * Naba Kumar Sahu

**DOI:** https://doi.org/10.5281/zenodo.20813461

**Abstract**

Corrosion is a natural electrochemical process that causes the deterioration of metals and alloys due to interactions with their environment. It results in significant economic losses, safety hazards, and environmental concerns across industries such as construction, transportation, marine engineering, and oil and gas production. This paper reviews the fundamental mechanisms of corrosion, its major forms, factors affecting corrosion rates, and modern prevention and control methods. Special emphasis is placed on electrochemical principles, microbiologically influenced corrosion, and corrosion protection strategies including coatings, cathodic protection, and corrosion inhibitors. Understanding corrosion behaviour is essential for improving material durability and reducing maintenance costs.

**Manuscript Information**

- **ISSN No:** 2583-7397
- **Received:** 05-05-2026
- **Accepted:** 16-06-2026
- **Published:** 23-06-2026
- **IJCRM:**5(3); 2026: 1097-1102
- **©2026, All Rights Reserved**
- **Plagiarism Checked:** Yes
- **Peer Review Process:** Yes

**How to Cite this Article**

Sahu N K. Corrosion: Mechanisms, Types, Effects, And Prevention Techniques. Int J Contemp Res Multidiscip. 2026;5(3):1097-1102.

**Access this Article Online**

www.multiarticlesjournal.com

**KEYWORDS:** Corrosion, Electrochemical degradation, Galvanic corrosion, Corrosion inhibitors, Cathodic protection, Material failure.

## 1. INTRODUCTION

Corrosion is defined as the gradual destruction of metals through chemical or electrochemical reactions with the surrounding environment. It is one of the most significant causes of material degradation and structural failure worldwide. According to corrosion studies, global economic losses due to corrosion amount to trillions of dollars annually. Corrosion affects bridges, pipelines, ships, reinforced concrete structures, and industrial equipment.

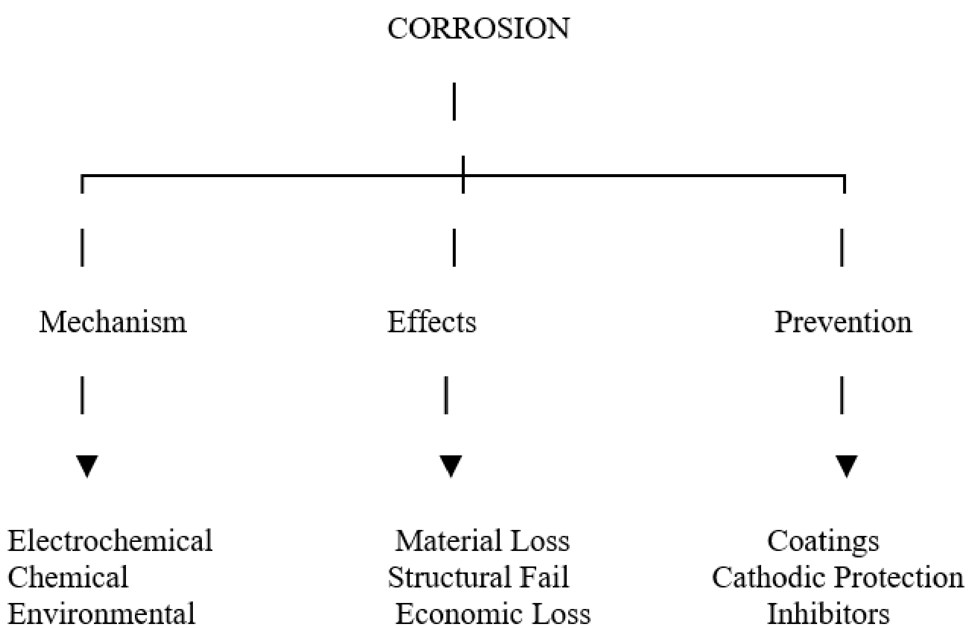
The thermodynamic tendency of metals to return to their lower-energy oxide state drives corrosion processes. While some metals form protective passive films, others experience rapid deterioration under aggressive environmental conditions.

Corrosion is the gradual deterioration of a metal or alloy due to chemical or electrochemical reactions with its surrounding environment. It is a naturally occurring process that affects almost all metallic materials and has significant economic, environmental, and safety implications. Metals are generally extracted from ores through energy-intensive processes, and corrosion represents the tendency of these refined metals to return to their more stable, lower-energy states, such as oxides, hydroxides, or sulfides. As a result, corrosion is considered an inevitable challenge in engineering and industrial applications.

The impact of corrosion is widespread and can be observed in numerous sectors, including construction, transportation, marine engineering, aerospace, power generation, and the oil and gas industry. Corrosion can lead to structural failures, equipment breakdowns, increased maintenance costs, production losses, and even catastrophic accidents that threaten human safety and the environment. According to global studies, corrosion-related costs account for approximately 3–4% of the world's Gross Domestic Product (GDP), highlighting the importance of effective corrosion management and prevention strategies.

Corrosion occurs through various mechanisms depending on the material and environmental conditions. Common forms include uniform corrosion, galvanic corrosion, pitting corrosion, crevice corrosion, intergranular corrosion, and stress corrosion cracking. Factors such as temperature, humidity, pH, oxygen concentration, salinity, and the presence of pollutants significantly influence the rate and severity of corrosion. Understanding these factors is essential for predicting material performance and selecting appropriate protection methods.

Advances in materials science and corrosion engineering have led to the development of numerous corrosion control techniques, including protective coatings, cathodic protection systems, corrosion inhibitors, and the use of corrosion-resistant alloys. Recent innovations such as nanostructured coatings, smart monitoring systems, and self-healing materials have further improved corrosion mitigation efforts. Therefore, a comprehensive understanding of corrosion mechanisms and prevention methods is crucial for enhancing the durability, reliability, and sustainability of engineering structures and industrial equipment.




### 2. Fundamentals of Corrosion

Corrosion is primarily an electrochemical phenomenon involving anodic and cathodic reactions.

**Anodic Reaction**

Metal dissolution occurs at the anode:

$$M \rightarrow M^{n+} + ne^-$$

Example:

$$Fe \rightarrow Fe^{2+} + 2e^-$$

**Cathodic Reaction**

In acidic solutions:

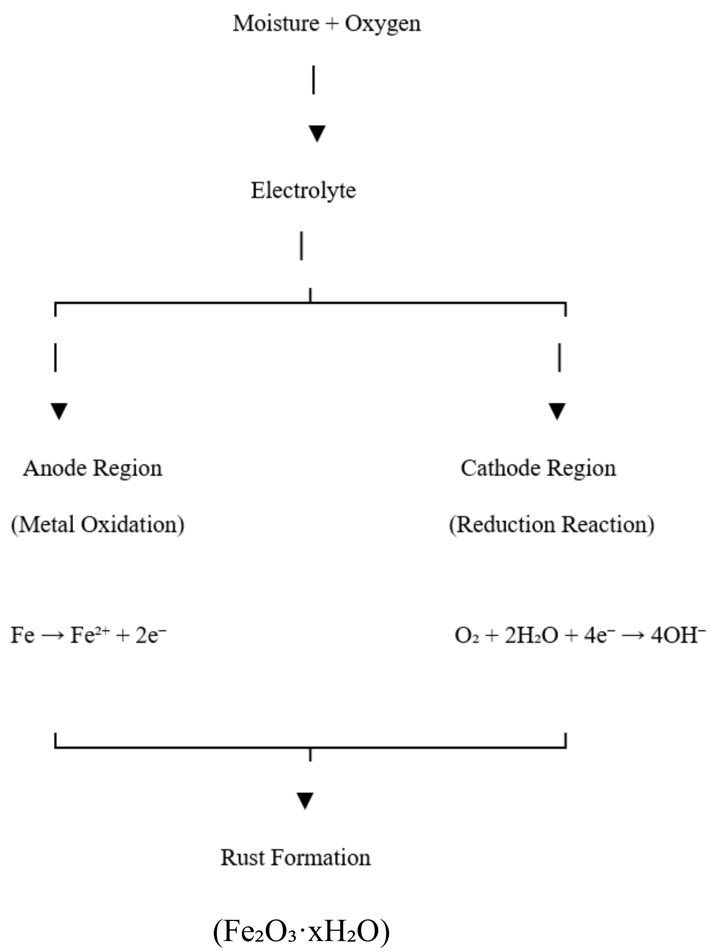
$2H^+ + 2e^- \rightarrow H_2$

In neutral or alkaline solutions:

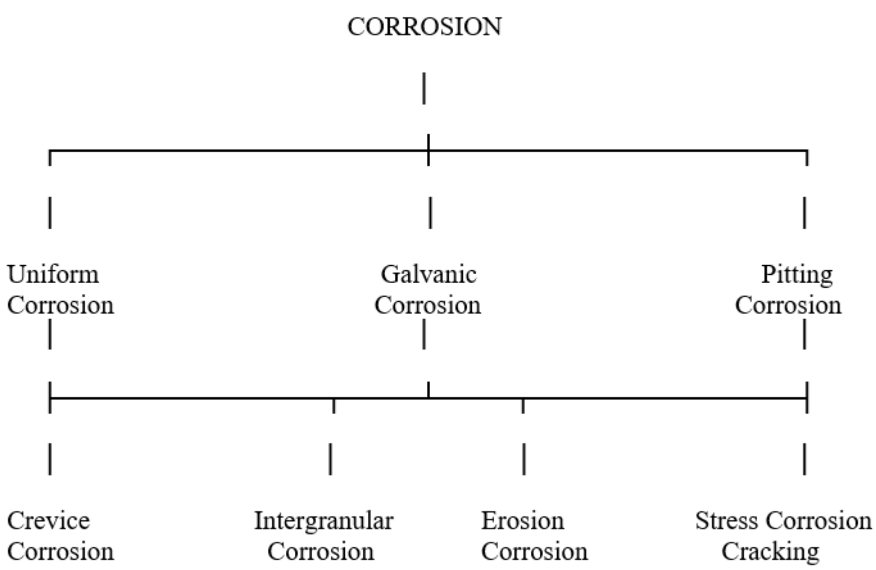
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

The simultaneous occurrence of these reactions results in metal degradation.

**Corrosion Mechanism Diagram:**




**3. Types of Corrosion**



### 3.1 Uniform Corrosion
Uniform corrosion occurs evenly across the metal surface and is the most common form. Although predictable, it can significantly reduce material thickness over time.

### 3.2 Galvanic Corrosion
Occurs when two dissimilar metals are electrically connected in an electrolyte. The more active metal acts as an anode and corrodes preferentially.

### 3.3 Pitting Corrosion
A highly localized form of corrosion resulting in small cavities or pits. It is particularly dangerous because it can lead to sudden failure.

### 3.4 Crevice Corrosion
Develops in confined spaces where oxygen concentration differs from surrounding areas, creating localized electrochemical cells.

### 3.5 Intergranular Corrosion
Occurs along grain boundaries due to compositional changes or precipitation of secondary phases.

### 3.6 Stress Corrosion Cracking (SCC)
Results from the combined action of tensile stress and a corrosive environment, producing cracks that can propagate rapidly.

### 3.7 Microbiologically Influenced Corrosion (MIC)
Caused by microorganisms that alter local electrochemical conditions and accelerate corrosion.

## 4. Factors Affecting Corrosion
Several environmental and material-related factors influence corrosion rates:


### Environmental Factors
- Temperature
- Humidity
- pH
- Dissolved oxygen
- Salinity
- Pollutants

### Material Factors
- Composition of metal
- Surface condition
- Grain structure
- Mechanical stress
- Presence of protective films

## 5. Effects of Corrosion
Corrosion causes:
- Structural failures
- Equipment breakdown
- Increased maintenance costs
- Environmental pollution
- Safety hazards
- Reduced operational efficiency

Industries such as oil and gas, transportation, aerospace, and marine sectors are particularly vulnerable to corrosion-related failures.

## 6. Corrosion Prevention and Control
Corrosion prevention and control are essential for extending the service life of metallic structures, reducing maintenance costs, and ensuring operational safety. Various methods have been developed to minimize corrosion by either modifying the environment, protecting the metal surface, or altering the electrochemical processes responsible for corrosion.

One of the most widely used methods is the application of protective coatings, which act as barriers between the metal surface and the corrosive environment. These coatings may be organic, such as paints and polymers, or inorganic, such as metallic coatings like zinc galvanization. Coatings effectively prevent moisture, oxygen, and aggressive ions from reaching the metal surface.

Cathodic protection is another effective technique used for pipelines, storage tanks, and marine structures. In this method, the metal structure is made the cathode of an electrochemical cell through the use of sacrificial anodes or impressed current systems. This significantly reduces the corrosion rate of the protected metal.

The use of corrosion inhibitors is common in industrial systems. These chemical compounds are added in small amounts to corrosive environments to reduce metal dissolution and slow corrosion reactions. Inhibitors are widely used in cooling systems, boilers, and oil and gas operations.

Proper material selection also plays a crucial role in corrosion control. Corrosion-resistant materials such as stainless steel, titanium, and nickel alloys are often chosen for aggressive environments. Additionally, environmental control measures, including reducing humidity, controlling temperature, and removing corrosive contaminants, can further minimize corrosion risks.

Combining these preventive strategies with regular inspection and monitoring programs provides an effective approach to corrosion management, improving the durability, reliability, and safety of engineering structures and industrial equipment.

### 6.1 Protective Coatings
Organic and inorganic coatings isolate metals from corrosive environments.

Examples:
- Epoxy coatings
- Polyurethane coatings
- Zinc-rich primers

### 6.2 Cathodic Protection

The metal structure is made the cathode of an electrochemical cell.

Methods:

- Sacrificial anode protection
- Impressed current protection

### 6.3 Corrosion Inhibitors

Chemical substances added in small quantities to reduce corrosion rates.

Examples:

- Chromates
- Phosphates
- Organic amines

### 6.4 Material Selection

Corrosion-resistant materials such as stainless steels, titanium alloys, and nickel-based alloys improve service life.

### 6.5 Environmental Modification

Reducing moisture, oxygen, or aggressive ions can significantly decrease corrosion rates.

### 7. Recent Advances in Corrosion Research

Recent developments include:

- Nanotechnology-based coatings
- Smart self-healing coatings
- Electrochemical monitoring sensors
- AI-based corrosion prediction models
- Advanced corrosion-resistant alloys

These technologies provide improved durability and real-time corrosion assessment.

## 8. CONCLUSION

Corrosion is a natural and unavoidable process that causes the gradual deterioration of metals through chemical or electrochemical reactions with their environment. It affects a wide range of industries, including construction, transportation, manufacturing, marine engineering, and energy production. Understanding the mechanisms of corrosion is essential for identifying how and why materials degrade over time. Various forms of corrosion, such as uniform, galvanic, pitting, crevice, and stress corrosion cracking, can lead to significant material damage and reduced service life of engineering components.

The effects of corrosion are far-reaching, resulting in economic losses, increased maintenance costs, reduced efficiency, safety hazards, and potential environmental damage. In severe cases, corrosion can cause structural failures that endanger human lives and disrupt industrial operations. Therefore, effective corrosion management is a critical aspect of engineering design and maintenance.

Several prevention techniques are available to minimize the impact of corrosion. These include the application of protective coatings, cathodic and anodic protection methods, the use of corrosion-resistant materials, environmental control, and corrosion inhibitors. Regular inspection and maintenance further help in detecting corrosion at an early stage and preventing costly failures.

In conclusion, corrosion remains a major challenge in engineering and industry, but its adverse effects can be significantly reduced through proper understanding, monitoring, and implementation of suitable prevention strategies, thereby improving safety, reliability, and the longevity of materials and structures.

## REFERENCES


1. Revie RW, Uhlig HH. *Corrosion and corrosion control*. 4th ed. Hoboken (NJ): Wiley; 2011.
2. Fontana MG. *Corrosion engineering*. 3rd ed. New York: McGraw-Hill; 1986.
3. Jones DA. *Principles and prevention of corrosion*. 2nd ed. Upper Saddle River (NJ): Prentice Hall; 1996.
4. Frankel GS. Pitting corrosion of metals. *J Electrochem Soc*. 1998;145(6):2186-2198. doi:10.1149/1.1838615.
5. Little BJ, Wagner P, Mansfeld F. Microbiologically influenced corrosion of metals and alloys. *Int Mater Rev*. 1991;36(1):253-272. doi:10.1179/imr.1991.36.1.253.
6. Little BJ, Lee JS. Microbiologically influenced corrosion: an update. *Corros Eng Sci Technol*. 2014;49(5):384-393. doi:10.1179/1743280414Y.0000000035.
7. Xu D, Gu T, Lovley DR. Microbially mediated metal corrosion. *Nat Rev Microbiol*. 2023;21:705-718. doi:10.1038/s41579-023-00920-3.
8. Betts AJ, Boulton LH. Crevice corrosion: review of mechanisms, modelling, and mitigation. *Br Corros J*. 1993;28(4):279-296. doi:10.1179/000705993799156299.
9. Dasgupta D. Mechanism of atmospheric corrosion of steel. *Br Corros J*. 1969;4(3):111-120. doi:10.1179/000705969798325451.
10. Somerscales EFC. Fundamentals of corrosion fouling. *Br Corros J*. 1999;34(2):95-104. doi:10.1179/000705999101500752.
11. Ahmad Z. *Principles of corrosion engineering and corrosion control*. Oxford: Butterworth-Heinemann; 2006.
12. Schweitzer PA. *Fundamentals of corrosion: mechanisms, causes and preventive methods*. Boca Raton (FL): CRC Press; 2010.
13. Scully JR, et al. One-dimensional wormhole corrosion in metals. 2022. Available from: https://doi.org/10.48550/arXiv.2203.16312
14. Matamoros-Veloza A, Barker R, Vargas S, Neville A. Mechanistic insights of dissolution and mechanical

breakdown of $FeCO_3$ corrosion films. 2020. Available from: https://doi.org/10.48550/arXiv.2009.11711

15. Korec E, Jirasek M, Wong HS, Martínez-Pañeda E. A phase-field chemo-mechanical model for corrosion-induced cracking in reinforced concrete. 2023. Available from: https://doi.org/10.48550/arXiv.2306.01903



**About the Author**

**Naba Kumar Sahu** is a Lecturer in Chemistry at R.D.S. Degree Mahavidyalaya, Kundabai, Odisha, India. He is dedicated to teaching and mentoring students in the field of chemistry. His academic interests include chemical sciences, higher education, and fostering scientific knowledge through effective classroom instruction and scholarly engagement.