

# Assessment Of Groundwater Quality Using Physico-Chemical Parameters: A Comprehensive Review

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**Abstract-** In many parts of the world, especially in developing nations, groundwater is an essential source of agricultural and drinking water. However, the quality of groundwater has drastically declined due to fast industrialization, urbanization, and agricultural activity. Some of the main reasons of its contamination are residential and commercial waste, landfills, inadequate drainage systems, seepage via sewage lines, agricultural practices including heavy fertilizer and pesticide usage, irregular rainfall, and poor management. In order to determine whether water is suitable for home, agricultural, and industrial applications, this review study examines groundwater quality using important physicochemical characteristics. In connection with the water quality standards set by the Bureau of Indian Standards, significant parameters like pH, total dissolved solids (TDS), hardness, alkalinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, chlorides, sulphates, and heavy metals are examined.

**Keywords:** Groundwater, Dissolved solids, pH, Heavy metals, Pesticides.

## I. INTRODUCTION

One of the most significant natural resources, groundwater is the world's main supplier of industrial, agricultural, and drinking water [1]. A sizable section of the populace in many developing nations, like India, relies on groundwater for everyday household requirements since it is easily accessible and reasonably priced [2]. Because groundwater naturally filters through soil and geological formations, it is typically thought to be cleaner than surface water [3]. However, its sustainability and quality have been severely impacted by growing human activity. Groundwater quality has declined as a result of rapid urbanization, industrial expansion, intensified agriculture, and inappropriate waste disposal methods. Natural geochemical processes, sewage infiltration, industrial effluents, and agricultural runoff are some of the ways that contaminants including nitrates, heavy metals, dissolved salts, and organic pollutants get into groundwater systems [4]. Agriculture, environmental stability, and human health are all seriously threatened by poor

groundwater quality. Contaminated groundwater is frequently associated with methemoglobinemia (blue baby syndrome), fluorosis, waterborne illnesses, and other medical conditions [5], [6]. To ascertain if groundwater is suitable for industrial, agricultural, and drinking uses, its quality must be assessed. Because they offer quantifiable markers of chemical composition and pollution levels, physicochemical parameters are essential for assessing the quality of water[7]. pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness, alkalinity, dissolved oxygen (DO), chemical and biochemical oxygen demand (BOD and COD), chlorides, sulphates, nitrates, and the presence of heavy metals are important metrics that are often utilized. To assess water appropriateness, these criteria are contrasted with the standard norms established by the Bureau of Indian Standards [8].

It is essential to comprehend physicochemical properties in order to identify pollution patterns, evaluate potability, make sure irrigation is appropriate, and create long-term groundwater management plans [9]. Particularly in areas undergoing fast industrialization, intensive agriculture, and urbanization, ongoing observation and evaluation are crucial. Thus, assessing groundwater using physicochemical characteristics offers a scientific foundation for safeguarding water resources and guaranteeing the supply of clean water for current and future populations [4], [10].

## II. SIGNIFICANCE OF PHYSICO-CHEMICAL PARAMETERS IN GROUNDWATER QUALITY

Groundwater's chemical makeup, mineral content, and the existence of dissolved materials from both natural geochemical processes and human activity are all reflected in its physicochemical properties, which are essential markers of groundwater quality [4]. In addition to supporting the identification of pollution or degradation in quality, their assessment aids in determining whether groundwater is suitable for drinking and household usage [10]. The Bureau of Indian Standard IS: 10500-2012 specify the permitted limits of the physicochemical parameters of groundwater, which define its quality and appropriateness for human use [11].

## 2.1 Physical parameters

These describe the observable and measurable physical characteristics of groundwater.

### 1. Temperature

- Influences chemical reactions, solubility of gases, and microbial activity.
- Affects dissolved oxygen and taste.

### 2. Color

- Indicates presence of dissolved organic matter, iron, or manganese.

### 3. Oduor & Taste

- May indicate contamination by organic matter, hydrogen sulfidic, or industrial pollutants.

### 4. Turbidity

- Caused by suspended particles (clay, silt, microorganisms).
- Measured in NTU.

### 5. Total Dissolved Solids (TDS)

- Sum of dissolved inorganic and organic substances.
- Indicator of salinity and mineralization.

### 6. Electrical Conductivity (EC)

- Measures ionic content of water.
- Directly related to TDS.

### 7. Total Suspended Solids (TSS)

- Particles not dissolved in water.

## 2.2 Chemical Parameters

These determine water chemistry and suitability for drinking and irrigation.

### A. General Chemical Parameters

pH

- Indicates acidity/alkalinity.
- Influences solubility of metals and minerals.  
Total Hardness (TH)

- Caused by calcium and magnesium.
- Expressed as  $\text{CaCO}_3$ .  
Alkalinity
- Capacity of water to neutralize acids.
- Due to bicarbonates, carbonates, hydroxides.  
Acidity
- Presence of mineral acids,  $\text{CO}_2$ , etc.  
Dissolved Oxygen (DO)
- Indicates biological activity and organic pollution.  
Biological Oxygen Demand (BOD)
- Oxygen required by microorganisms to decompose organic matter.  
Chemical Oxygen Demand (COD)
- Measures total oxygen required to oxidize organic and inorganic substances.

### B. Major Cations

- Calcium ( $\text{Ca}^{2+}$ )
- Magnesium ( $\text{Mg}^{2+}$ )
- Sodium ( $\text{Na}^+$ )
- Potassium ( $\text{K}^+$ )

### C. Major Anions

- Chloride ( $\text{Cl}^-$ )
- Sulfate ( $\text{SO}_4^{2-}$ )
- Bicarbonate ( $\text{HCO}_3^-$ )
- Carbonate ( $\text{CO}_3^{2-}$ )
- Nitrate ( $\text{NO}_3^-$ )
- Nitrite ( $\text{NO}_2^-$ )
- Fluoride ( $\text{F}^-$ )
- Phosphate ( $\text{PO}_4^{3-}$ )

### 3. Trace and Heavy Metals

Important for toxicity assessment:

- Iron (Fe)
- Manganese (Mn)
- Lead (Pb)
- Cadmium (Cd)
- Chromium (Cr)
- Arsenic (As)
- Nickel (Ni)
- Zinc (Zn)
- Copper (Cu)
- Mercury (Hg)

### 4. Derived Water Quality Indices

For review papers, it is important to include assessment tools:

Water Quality Index (WQI)

- Aggregates multiple parameters into a single value.
- Sodium Adsorption Ratio (SAR)
- Important for irrigation suitability.
- Residual Sodium Carbonate (RSC)
- Permeability Index (PI)
- Kelly’s Ratio (KR)
- Magnesium Hazard (MH)

**5. Hydrochemical Facies & Graphical Methods**

- Piper diagram
- Gibbs diagram
- Wilcox diagram
- Schoeller diagram

**6. Standards for Comparison**

For a strong review paper, compare values with international standards such as:

- World Health Organization (WHO) drinking water guidelines
- Bureau of Indian Standards (BIS 10500)
- United States Environmental Protection Agency (USEPA)

**7. Suggested Structure for Your Review Paper**

1. Introduction to groundwater contamination
2. Classification of physico-chemical parameters
3. Analytical methods used for determination
4. Standards and permissible limits
5. Case studies from different regions
6. Use of WQI and multivariate statistical analysis
7. Conclusions and future perspectives

**Table – 1: Physical parameter IS 10500-2012**

| parameter               | units          | Test method                | WHO acceptable limit  |
|-------------------------|----------------|----------------------------|-----------------------|
| pH                      |                | Digital electrode pH meter | 6.5- 8.5              |
| Turbidity               | NTU            | Nephelometer               | ≤ 5 NTU IS 10500:2012 |
| Electrical conductivity | uS/cm          | Digital conductivity meter | 1500uS/cm             |
| Temperature             | Degree celcius | an analytical thermometer  | 5°C and 20°C          |

**Table - 2: Chemical parameters IS 10500-2012**

| Parameters       | units | acceptable limit | Permi. limit |
|------------------|-------|------------------|--------------|
| Calcium          | Mg/l  | 75               | 200          |
| Chloride         | Mg/l  | 250              | 1000         |
| Magnesium        | Mg/l  | 30               | 100          |
| Nitrate          | Mg/l  | 45               |              |
| Total alkalinity | Mg/l  | 200              | 600          |
| Sulphate         | Mg/l  | 200              | 400          |

**3. Health Effect of different Physicochemical**

**Characteristics of Ground Water**

Excessive levels of physicochemical parameters in groundwater significantly endanger public health. Low pH can cause acidosis, while high turbidity and TDS lead to chemical adsorption, stomach disorders, and unpleasant tastes. Excessive hardness and alkalinity are linked to cardiovascular issues and physical growth retardation. Dangerous concentrations of nitrate and fluoride are associated with methemoglobinemia, gastric cancer, and debilitating fluorosis. Furthermore, mineral imbalances in calcium, magnesium, chloride, and iron can result in kidney stones, hypertension, laxative effects, and lethal systemic toxicity.

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