# Regulatory Standards for Safe Drinking Water

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# INTRODUCTION

Regulatory standards for water represent a crucial framework established by government authorities to ensure the safety, quality, and sustainable use of water resources. These standards are designed with a primary focus on protecting public health by setting stringent criteria for acceptable levels of contaminants in drinking water, thereby preventing the spread of waterborne diseases and ensuring the well-being of communities. Simultaneously, the standards address environmental concerns by placing limits on pollutants discharged into water bodies, with the goal of preserving aquatic ecosystems, biodiversity, and overall environmental health. Furthermore, the regulations are crafted to support the sustainability of water-dependent industries, recognizing their pivotal role in economic development. By promoting responsible water usage, regulating discharge practices, and encouraging efficient resource management, regulatory standards contribute to a balanced interplay between human needs, environmental conservation, and industrial progress.

Beyond specifying parametric values, these standards employ a multifaceted approach. They provide explicit guidelines for sampling protocols, methods, and frequencies, ensuring a thorough assessment of water quality. Consideration is given to the characteristics of water sources and potential contaminant sources, with detailed instructions on collecting representative samples. Regular assessments through defined sampling frequencies monitor variations over time. Analytical methods prescribed in these standards emphasize accuracy and reliability, fostering consistency in testing procedures. Laboratory accreditation, often integral to these standards, ensures adherence to rigorous quality control measures, bolstering the credibility of reported results.

Additionally, some standards incorporate calculations for determining compliance levels, employing processes such as averaging to assess overall water quality. Certain documents also feature intricate requirements for statistically treating results, accommodating temporal and seasonal variations, summing related parameters, and addressing mathematical treatment for seemingly anomalous findings. This meticulous approach underscores the necessity of a comprehensive understanding of water quality dynamics, ensuring that the standards remain adaptable to varying conditions and factors influencing water composition. Ultimately, the complexity and specificity of these standards highlight their crucial role in promoting a meticulous and scientifically rigorous approach to assessing and maintaining the quality of drinking water.

# Global Regulatory Standards

1. **World Health Organization (WHO):** The WHO sets international guidelines for drinking water quality to protect public health. These guidelines cover parameters such as microbial contaminants, chemical substances, and physical characteristics of water.

2. **Environmental Protection Agency (EPA):** In the United States, the EPA is a key regulatory agency responsible for setting and enforcing water quality standards. The Clean Water Act empowers the EPA to establish and oversee standards for surface water quality, wastewater discharge, and stormwater management.

3. **European Union (EU):** The EU Water Framework Directive establishes a framework for water policy across member states. It addresses the quality of surface water, groundwater, and the protection and sustainable use of water resources.

4. **ISO Standards:** The International Organization for Standardization (ISO) develops international standards for various industries, including water. ISO 14046 focuses on water footprint assessment, while ISO 24510 and ISO 5667 provide guidelines for sampling and analysis.

5. **National Standards:** Most countries have their own national standards and regulations regarding water quality. These standards may cover parameters like permissible levels of pollutants, monitoring requirements, and guidelines for water treatment and distribution.

6. **Bureau of Indian Standards (BIS):** BIS is the national standards body of India, responsible for the formulation and implementation of standards across various sectors, including water quality. IS 10500 is a comprehensive standard that covers a wide range of parameters to ensure the safety of drinking water.

# Organoleptic and Physical Parameters

Organoleptic and physical parameters are categories of characteristics used to assess the sensory and structural aspects of water. These parameters are essential in evaluating water quality, as they provide information about the appearance, taste, odour, and physical properties of the water.

## Organoleptic Parameters:

**Colour:** The visual perception of watercolour can indicate the presence of natural or man-made substances. For example, the presence of organic matter or certain minerals can impart a colour to the water.

| | |
|---|---|
| Colour, Hazen Units | |
| IS 10500-2012 | Acceptable: 5Hz, Permissible: 15Hz |
| Risk or Effects | Visible Tint, Acceptance decreases |
| Sources | Suspended material, soil runoff, presence of tannins and lignins, minerals like iron, copper, manganese, and organic wastes |
| Treatment | |

**Odour:** The smell of water can be indicative of various factors, including the presence of pollutants or natural substances. Unpleasant odours may suggest contamination or decay.

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|---|---|
| Odour | |
| IS 10500-2012 | Agreeable |
| Risk or Effects | Rotten egg, musty, chemical smell |
| Sources | Chlorine, hydrogen sulphide, presence of iron, manganese, chlorides, sulphates, aluminium, copper, contamination due to sewage and organic matter, methane gas |
| Treatment | Activated carbon, air stripping, oxidation, filtration, distillation, ion exchange |

**Taste:** The taste of water is assessed to identify any unusual or undesirable flavours. Certain minerals or contaminants can impart distinct tastes to water, affecting its palatability.

## Physical Parameters:

**Temperature:** Water temperature is a critical physical parameter that influences the solubility of gases, the growth of aquatic organisms, and overall ecosystem dynamics. Fluctuations in temperature can impact the health of aquatic ecosystems.

**Turbidity:** Turbidity measures the cloudiness or haziness of water caused by suspended particles. High turbidity levels can affect light penetration, aquatic plant growth, and the overall health of aquatic organisms.

| Turbidity NTU Max | |
|---|---|
| IS 10500: 2012 | Acceptable unit: 1 NTU<br>Permissible limit: 5 NTU |
| Risks or effects | Cloudiness or haziness |
| Sources | High Sediment deposition due to pollution and industrial activities like construction, mining, quarrying, and agriculture, due to the presence of organic matter such as phytoplankton |
| Treatment | Settling or filtration processes using sand filtration, settling tanks, and clarifiers |

**Total Dissolved Solids (TDS):** TDS represents the amount of inorganic and organic substances dissolved in water. Elevated TDS levels can affect the taste of water and may indicate the presence of minerals or salts.

| Total dissolved solids, mg/l, Max | |
|---|---|
| IS 1500: 2012 | Acceptable limit: 500 mg/l<br>Permissible: 2000 mg/l |
| Risks or effects | Hardness, scaly deposits, sediments, cloudy coloured water, salty or bitter taste, corrosion of pipes and fittings |

| | |
|---|---|
| Sources | Salts, heavy metals and organic compounds found in agricultural and urban runoff, wastewater from households, and industries, sewage from urban and rural areas, hazardous wastes from landfills |
| Treatment | Reverse osmosis, distillation, and deionization by ion exchange |

**Conductivity:** Conductivity measures the ability of water to conduct an electrical current, which is influenced by dissolved ions. It is an indirect indicator of TDS and can be used to assess water quality.

**pH (Hydrogen Ion Concentration):** pH measures the acidity or alkalinity of water. It is crucial for the survival of aquatic life and can influence the effectiveness of water treatment processes.

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|---|---|
| pH | |
| IS 10500: 2012 | Acceptable limit: 6.5-8.5, Permissible: No relaxation |
| Risks or effects | Low pH – corrosion leading to metallic taste<br>High pH – bitter/soda taste, leads to deposits |
| Sources | Natural |
| Treatment | Increase pH by soda ash, decrease pH with white vinegar/citric acid |

**Total Suspended Solids (TSS):** TSS refers to the concentration of suspended particles in water. Excessive TSS levels can degrade water quality, impacting aquatic habitats and water treatment processes.

# Chemical Parameters

Water quality is assessed based on various chemical parameters that reflect the presence and concentration of different substances in water. These chemicals can originate from natural sources, human activities, or a combination of both.

**Aluminium:** Aluminium is a naturally occurring element that can be found in water sources, and its presence can be influenced by both natural processes and human activities.

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|---|---|
| Aluminium (as Al), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 0.03 mg/l<br>Permissible limit: 0.2 mg/l |
| Risks or effects | High risk associated with dialysis patients |
| Sources | Rock and soil leaching |
| Treatment | Portable cation exchange, distillation, reverse osmosis |

**Ammonia:** Ammonia ($NH_3$) is a compound consisting of one nitrogen atom and three hydrogen atoms. In the context of water, ammonia is an important parameter in water quality assessment, and its presence can be influenced by natural processes, industrial activities, and agricultural practices.

| | |
|---|---|
| Ammonia (as NH3), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 0.5 mg/l<br>Permissible limit: No relaxation |
| Risks or effects | None proposed for humans, but toxic for aquatic life |
| Sources | Disinfection with chloramines, wastes, fertilizers and natural processes |
| Treatment | Ion exchange with zeolite, sodium alumina silicate zeolites, distillation |

**Barium:** Barium is a chemical element with the symbol Ba and atomic number 56. In the context of water quality, barium may be present as a result of both natural processes and human activities.

| | |
|---|---|
| Barium (as Ba), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 0.7 mg/l<br>Permissible limit: No relaxation |
| Risks or effects | Difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach irritation, brain swelling, muscle weakness, and damage to the liver, kidney, heart, and spleen |
| Sources | Mineral deposits, disposal of drilling wastes, smelting of copper, motor vehicle parts manufacturing |
| Treatment | Cation exchange, reverse osmosis, distillation |

**Iron:** Iron is a chemical element with the symbol Fe and atomic number 26. In the context of water quality, iron is a common parameter that is often monitored due to its presence in natural water sources

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|---|---|
| Iron (as Fe), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 0.3 mg/l<br>Permissible limit: No relaxation |
| Risks or effects | Brackish colour, rusty sediment, bitter or metallic taste, brown-green strains, iron bacteria, discolouration of beverages |
| Sources | Leaching of cast iron pipes in water, distribution systems, natural |
| Treatment | Oxidizing filter, greens-sand mechanical filter |

**Manganese:** Manganese is a chemical element with the symbol Mn and atomic number 25. It is commonly found in the Earth's crust and can be present in water sources, either naturally or due to human activities.

| | |
|---|---|
| Manganese (as Mn), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 0.1 mg/l<br>Permissible limit: 0.3 mg/l |
| Risks or effects | Can stain laundry and fixtures at 0.2 mg/l, cause discolouration and leave an unpleasant taste to water, and may affect brain development in infants and young children |
| Sources | Landfills, deposits in rock and soil |
| Treatment | Oxidizing filter, ion exchange, chlorination, green-sand mechanical filters |

**Sulphate**: Sulphate, or sulphate, is a chemical ion composed of sulphur and oxygen, with the chemical formula $SO_4^{2-}$. It is an essential and naturally occurring component in water, deriving from the dissolution of minerals in rocks and soils

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|---|---|
| Sulphate (as SO4), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 200 mg/l<br>Permissible limit: 400 mg/l |
| Risks or effects | Bitter, medicinal taste, scaly deposits, corrosive, laxative effects, rotten egg odour from hydrogen sulphide gas formation |
| Sources | Urban and rural sewage, industrial wastes, by-products of coal mining, natural deposits or salts |
| Treatment | Ion exchange, distillation, reverse osmosis |

**Nitrate:** Nitrate ($NO_3^-$) is a chemical ion composed of nitrogen and oxygen. It is a common form of nitrogen in the environment and can be found in water as a result of natural processes and human activities.

| | |
|---|---|
| Nitrate (as NO3), mg/l, Max | |
| IS 10500: 2012 | Acceptable limit: 45 mg/l<br>Permissible limit: No relaxation |
| Risks or effects | Methemoglobinemia or blue baby disease in infants |
| Sources | Human sewage and livestock manure, fertilizers, erosion of natural deposits |
| Treatment | Anion exchange, nitrate selective anion, exchange resins, distillation, electrodialysis |

**E coliform bacteria**: Escherichia coli (E. coli) bacteria are a specific type of coliform bacteria commonly used as indicators of faecal contamination in water. While some coliform bacteria are naturally present in the environment and are not necessarily harmful, the presence of E. coli specifically is an important indicator of potential faecal contamination and the possible presence of harmful pathogens.

| | |
|---|---|
| E coliform bacteria | |
| IS 10500: 2012 | Nil/100ml |
| Risks or effects | Gastrointestinal tract infections |
| Sources | Contaminated animal waste, sewage contaminated with faecal matter, household wastewater, polluted stormwater and agricultural runoffs, naturally occurring |
| Treatment | Chlorination, ultraviolet light, distillation, ozonation |

# Regulatory Compliance

Regulatory compliance for water quality refers to adherence to the rules, guidelines, and standards set by regulatory authorities to ensure that water resources meet specified quality and safety criteria. Compliance is essential to protect public health, preserve the environment, and maintain the sustainability of water sources. Here are key aspects of regulatory compliance for water quality:

1. **Water Quality Standards:**
    - Regulatory bodies, such as environmental agencies or health departments, establish water quality standards that outline permissible levels of various contaminants and parameters in water. These standards address factors like microbiological contaminants, chemical substances, physical characteristics, and more.
2. **Monitoring and Testing:**
    - Entities responsible for water management, including water treatment plants, industries, and municipal authorities, are required to regularly monitor and test water quality. This involves collecting samples, conducting analyses, and comparing the results to established standards.
3. **Reporting Requirements:**
    - Compliance often involves reporting the results of water quality monitoring to the relevant regulatory authorities. Timely and accurate reporting is crucial for transparency and allows regulators to assess compliance with established standards.
4. **Permitting and Licensing:**
    - Industries, wastewater treatment plants, and other entities discharging effluents into water bodies may be required to obtain permits or licenses. These permits typically outline specific conditions and limits to ensure that discharges comply with water quality standards.
5. **Treatment and Mitigation Measures:**
    - Entities responsible for water supply and treatment must implement appropriate measures to meet or exceed water quality standards. This may involve upgrading treatment facilities, implementing

pollution prevention strategies, and taking corrective actions to address non-compliance.

6. **Public Notification:**
    - In cases where water quality standards are not met and there is a potential risk to public health, regulatory authorities may require public notification. This ensures that consumers are informed about any potential risks and can take necessary precautions.
7. **Enforcement and Penalties:**
    - Regulatory bodies have the authority to enforce compliance through inspections, audits, and the imposition of penalties for non-compliance. Penalties may include fines, permit revocation, or legal action.
8. **Adherence to Specific Regulations:**
    - Different regions may have specific regulations governing water quality. For example, the Clean Water Act in the United States sets forth regulatory requirements for water quality, discharge permits, and pollution control.
9. **Adaptation to Changing Conditions:**
    - Regulatory compliance also involves adapting to changing conditions, emerging contaminants, or evolving scientific knowledge. Regulatory standards may be periodically updated to reflect the latest understanding of water quality and its impact on public health and the environment.

# Conclusion

In conclusion, water quality and regulatory standards serve as indispensable cornerstones in ensuring the safety, purity, and sustainability of water resources. The establishment of stringent standards by regulatory authorities globally is a testament to the commitment to protecting public health, ecosystems, and water-dependent industries. Water quality standards, encompassing a diverse array of parameters, provide a comprehensive framework for monitoring and assessing the condition of water sources. Rigorous adherence to these standards is crucial for preventing waterborne diseases, preserving biodiversity, and maintaining the delicate balance of aquatic ecosystems.

The regulatory compliance mechanisms, involving monitoring, testing, reporting, and enforcement, create a structured approach to upholding these standards. Entities are responsible for water management, treatment, and discharge are held accountable through permits, licenses, and potential penalties, ensuring a proactive commitment to maintaining water quality. Public notification mechanisms further enhance transparency, enabling communities to actively participate in safeguarding their water sources.

As environmental challenges evolve and scientific understanding deepens, the adaptive nature of regulatory standards becomes paramount. Regular updates and revisions ensure that standards remain at the forefront of addressing emerging issues and technological advancements. In essence, the intersection of water quality and regulatory standards signifies a comprehensive and dynamic approach to securing the availability of clean and safe water for current and future generations, embodying a commitment to environmental stewardship and human well-being.