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Physicochemical Parameters for Water-Environment Quality Testing: A Review

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Abstract

The increasing threat posed by contaminants in air, water, and soil is a pressing issue globally, exacerbated by population growth, industrialization, and agricultural practices. These factors contribute to significant water pollution, introducing harmful substances that compromise human health. Natural processes, such as weathering and soil leaching, alongside mining activities, further degrade water quality. Regular monitoring of drinking water is essential, as contaminated sources can lead to a variety of waterborne diseases, highlighting the necessity for reliable access to safe water for enhancing public health and quality of life. This study focuses on the critical assessment of various physicochemical parameters, including color, temperature, acidity, hardness, pH, sulfate, chloride, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and alkalinity, which are vital for evaluating water quality. Particular attention is given to heavy metals like lead (Pb), chromium (Cr), iron (Fe), and mercury (Hg), due to their potential for chronic toxicity in aquatic organisms and human populations. The research includes a comparative analysis of water samples, detailing physicochemical parameters to identify contamination levels. Furthermore, established guidelines for these parameters are presented to facilitate the evaluation of real-world water quality data. This investigation aims to underscore the importance of systematic water quality monitoring and management to safeguard public health and preserve aquatic ecosystems. The study addresses the global challenge of water pollution caused by population growth, industrialization, agriculture, and natural processes like weathering and mining. It emphasizes the health risks posed by contaminants in water, particularly heavy metals like lead, chromium, iron, and mercury, known for their chronic toxicity. The research focuses on assessing key physicochemical parameters, such as pH, hardness, DO, BOD, COD, and alkalinity, to evaluate water quality. A comparative analysis of water samples is conducted, referencing established guidelines to highlight contamination levels. The study underscores the critical need for systematic water quality monitoring and management to protect public health and aquatic ecosystems.

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INTRODUCTION

Water is vital for all life forms and constitutes about 70% of Earth's surface. However, rapid population growth, industrialization, and agricultural practices have led to significant water pollution, introducing harmful contaminants that threaten human health. Contaminated drinking water is linked to various waterborne diseases, making regular quality assessments essential. Natural impurities, industrial discharges, and the use of fertilizers further complicate water quality, resulting in heavy metal contamination and deteriorating health outcomes [1–3].

Physicochemical testing for contaminated water environment is crucial to determine water's suitability for drinking, agriculture, and industrial use. Key parameters include temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). Each parameter plays a significant role in assessing the overall quality and safety of water. For instance, temperature influences chemical reactions and aquatic life, while pH indicates corrosive potential and biological activity (Tables 1 and 2) [4–6].

Various studies in the Niger Delta Region of Nigeria and the world at large, highlight the alarming levels of pollutants in water sources, often exceeding permissible limits set by health organizations. Research has shown that untreated industrial effluents and agricultural runoff significantly affect water quality, posing health risks to humans and ecosystems alike. Moreover, long-term exposure to heavy metals through contaminated water can lead to chronic health issues and ecological damage (Tables 3 and 4) [7–9]. Comprehensive physicochemical analysis is vital for monitoring water quality and ensuring safe drinking water. Regular assessments can help mitigate health risks and promote sustainable water management practices in urban and rural areas alike (Table 5) [10, 11].

Table 1 presents the functional parameters at 75°C and 90°C, including bacterial count (THB), velocity, inverse substrate concentration (1/[S]), and utilization factors (1/[UF]). It highlights temperature-dependent variations in microbial activity and substrate utilization rates.

Table 2 presents the functional parameters at 105°C and 120°C, including bacterial count (THB, cfu/g), activity rate (velocity, cfu/g/h), inverse substrate concentration (1/[S], ppm), and utilization factor (1/[UF], cfu/g/h). Temperature influences bacterial activity and substrate utilization, showing temperature-dependent behavior.

Table 1. Functional Parameters (75°C and 90°C).

	Temp (°C)	THB (cfu/g)	Velocity (cfu/g/hr)	$1/[S]_{75}$ $(cfu/g/h)^{-1}$ $\times 10^{-4}$	$1/[UF]_{75}$ $(cfu/g/hr)^{-1}$ $\times 10^{-4}$	Temp (°C)	THF (cfu/g)	Velocity (cfu/g/h)	$1/[S]_{90}$ $(PPM)^{-1}$	$1/[UF]_{90}$ $(cfu/g/h)^{-1}$ $\times 10^{-4}$
0	75	200	-			90	200	-		
1	75	600	400	1.5	2.5	90	800	600	1.6	1.6
2	75	300	-300	1.7	-3.3	90	-300	-500	1.8	2
3	75	700	400	2.1	2.5	90	400	100	2.1	1
4	75	900	200	2.7	0.5	90	600	200	2.7	5
5	75	600	-300	3.6	-3.3	90	800	200	3.6	5
6	75	200	-400	4.4	-2.5	90	1000	200	4.5	5

Table 2. Functional Parameters (105°C and 120°C).

	Temp (°C)	THB (cfu/g)	Velocity $(cfu/g/h)$	$1/[S]_{105}$ $(cfu/g/h)^{-1}$ $X10^{-4}$	$1/[UF]_{105}$ $(cfu/g/h)^{-1}$ $\times 10^{-4}$	Temp (°C)	THF (cfu/g)	Velocity $(cfu/g/h)$	$1/[S]_{120}$ $(ppm)^{-1}$	$1/[UF]_{120}$ $(cfu/g/h)^{-1}$ $\times 10^{-4}$
0	105	200	-			120	200			
1	105	600	400	1.7	2.5	120	200	0	1.7	-
2	105	200	-400	1.8	-2.5	120	200	0	1.8	-
3	105	800	600	2.2	1.7	120	200	0	2.2	-
4	105	500	-300	2.9	-3.3	120	400	200	2.9	5
5	105	200	-300	3.7	-3.3	120	300	-100	3.7	-10
6	105	200	-300	4.6	-3.3	120	100	-200	4.8	-5

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Table 3. Functional Parameters (15°C and 30°C).

	Temp (°C)	THB (cfu/g)	Velocity $(cfu/g/h)$	$1/[S]_{15}$ $(cfu/g/h)^{-1}$ × 10^{-4}	$1/[UF]_{15}$ $(cfu/g/h)^{-1}$ × 10^{-4}	Temp (°C)	THF (cfu/g)	Velocity $(cfu/g/h)$	$1/[S]_{30}$ $(PPM)^{-1}$	$1/[UF]_{30}$ $(cfu/g/h)^{-1}$ × 10^{-4}
0	15	200	-			30	200	-		
1	15	200	0	1.4	-	30	400	200	1.5	5
2	15	200	0	1.6	-	30	800	400	1.6	2.5
3	15	200	0	2.0	-	30	1300	500	2.0	2
4	15	300	100	2.5	10	30	1500	200	2.6	5
5	15	300	0	3.3	-	30	-500	-500	3.4	-2
6	15	400	100	4.2	10	30	300	-300	4.2	-3.3

Table 4. Functional Parameters (45°C and 60°C).

	Temp (°C)	THB (cfu/g)	Velocity $(cfu/g/h)$	$1/[S]_{45}$ $(cfu/g/h)^{-1}$ × 10^{-4}	$1/[UF]_{45}$ $(cfu/g/h)^{-1}$ × 10^{-4}	Temp (°C)	THF (cfu/g)	Velocity $(cfu/g/h)$	$1/[S]_{60}$ $(ppm)^{-1}$	$1/[UF]_{60}$ $(cfu/g/h)^{-1}$ × 10^{-4}
0	45	200	-			60	200	-		
1	45	200	0	1.1	-	60	300	100	1.1	10
2	45	300	100	1.5	10	60	700	400	1.5	2.5
3	45	500	200	1.7	5	60	1600	900	1.7	1.1
4	45	800	300	2.1	3.3	60	1700	100	2.7	10
5	45	500	0	3.4	-	60	700	-900	3.5	-1.1
6	45	300	-5	4.2	-2	60	400	-300	4.3	-3.3

Table 5. Various analytical water quality parameters, their testing techniques, and guideline values according to World Health Organization (WHO) standards.

S.N.	Parameter	Technique Used	WHO Standard
1	Temperature	Thermometer	-
2	Color	Visual / color kit	-
3	Odor	Physiological sense	Acceptable
4	Electrical conductivity	Conductivity meter / Water analysis kit	-
5	pH	pH meter	6.5–9.5
6	Dissolved oxygen	Redox titration	-
7	Total hardness	Complexometric titration	200 ppm
8	Alkalinity	Acid–base titration	-
9	Acidity	Acid–base titration	-
10	Ammonia	UV-visible spectrophotometer	0.3 ppm
11	Bi carbonate	Titration	-
12	Biochemical oxygen demand (BOD.)	Incubation followed by titration	6
13	Carbonate	Titration	-
14	Chemical oxygen demand (COD)	COD digester	10
15	Chloride	Argentometric titration	250 ppm
16	Magnesium	Complexometric titration	150 ppm
17	Nitrate	UV-visible spectrophotometer	45 ppm
18	Nitrite	UV-visible spectrophotometer	3 ppm
19	Potassium	Flame photometer	-
20	Sodium	Flame photometer	200 ppm

Table 3 presents data on microbial activity at a temperature of 15°C. It includes measurements of total heterotrophic bacteria (THB) and total hydrocarbon-utilizing fungi (THF), their velocities, reciprocal substrate concentrations [1/S]15, and reciprocal fungal utilization rates [1/UF]15. The data highlights variations in microbial growth and hydrocarbon utilization under different conditions at a lower temperature.

Table 4 provides a comparative analysis of parameters measured at temperatures of 45°C and 60°C. The table includes data on total heterotrophic bacteria (THB), total hydrocarbon-utilizing fungi (THF), and their respective velocities, alongside parameters like reciprocal substrate concentration [1/S]45 and reciprocal fungal utilization rate [1/UF]45, with values varying across different conditions. These parameters are crucial for studying microbial activity and degradation kinetics in specific environments.

Table 5 summarizes water quality parameters, testing techniques (e.g., titration, spectrophotometry), and World Health Organization (WHO) standards. Key parameters include physical (temperature, color), chemical (pH, ammonia), and organic pollution indicators (BOD, COD). Methods involve instruments like thermometers, UV-visible spectrophotometers, and flame photometers. WHO standards specify values for pH (6.5–9.5), ammonia (0.3 ppm), and chloride (250 ppm), ensuring water safety.

CONCLUSION

In conclusion, the assessment of physicochemical parameters is essential for effective water quality management, particularly in the face of increasing pollution due to industrialization, agricultural practices, and population growth. This study underscores the importance of regular monitoring to ensure safe drinking water, which is critical for public health and environmental sustainability.

The analysis of key parameters, such as pH, DO, BOD, COD, and heavy metal concentrations, highlights the urgent need for stringent regulatory measures to mitigate contamination risks. By adhering to established guidelines and conducting comprehensive evaluations, we can safeguard aquatic ecosystems and protect human health from the adverse effects of polluted water. Systematic monitoring not only facilitates the identification of contamination sources but also promotes informed decision-making for sustainable water management.

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