Physico-Chemical and Microbiological Assessment of Kadayal River Water for Potability and Drinking Suitability Evaluation

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Abstract: Freshwater rivers play a vital role in meeting domestic, agricultural, and ecological demands. Continuous monitoring of river water quality is essential to ensure public health and sustainable water resource management. The present study evaluates the physico-chemical and microbiological characteristics of the Kadayal River water, Tamil Nadu, India, to assess its suitability for drinking purposes. A single water sample was collected and analyzed following standard procedures prescribed by IS 3025 and APHA methods. Parameters such as pH, electrical conductivity, total dissolved solids, alkalinity, hardness, major ions, nutrients, trace metals, turbidity, and microbial indicators were examined. The results were compared with Bureau of Indian Standards (BIS) drinking water limits. Most parameters were found to be well within permissible limits, indicating good water quality. Microbiological analysis confirmed the absence of total coliforms and E. *coli*, signifying minimal contamination. Microplastic analysis revealed a low abundance of predominantly fiber-shaped particles, suggesting limited anthropogenic influence at the sampling location. The study concludes that Kadayal River water at the sampling location is suitable for drinking after conventional treatment and highlights the importance of periodic monitoring to safeguard water quality.

Keywords: Kadayal River, Water Quality Assessment, Physico-Chemical Parameters, Microbiological Analysis, Drinking Water Standards

1. Introduction

Rivers are critical freshwater resources that support human civilization, agriculture, and ecosystems. However, rapid urbanization, agricultural runoff, and anthropogenic activities have

significantly deteriorated river water quality in many regions. Monitoring river water quality is essential to evaluate its suitability for drinking and to prevent waterborne diseases.

The Kadayal River is an important surface water source in the southern region of Tamil Nadu. Although it serves local communities for domestic and agricultural needs, limited scientific documentation exists regarding its water quality. Therefore, a systematic assessment of physico-chemical and microbiological parameters is necessary to understand its present condition.

This study aims to analyze the water quality of the Kadayal River using standard laboratory methods and to compare the results with BIS drinking water standards.

2. Study Area

The Kadayal River flows through Kanyakumari district, Tamil Nadu, India. The river supports local populations for domestic usage and irrigation. The sampling location was selected based on accessibility and representative flow conditions. The water sample was collected manually following standard sampling protocols.

2.1 Literature Review

Importance of River Water Quality Assessment

Rivers are vital sources of freshwater for domestic, agricultural, and industrial uses, particularly in developing regions where treated water supply is limited. However, rapid urbanization, industrial discharge, agricultural runoff, and improper waste disposal have significantly degraded river water quality, raising concerns about its suitability for drinking purposes. Consequently, systematic assessment of river water using physico-chemical and microbiological parameters has become essential for safeguarding public health and ensuring sustainable water resource management.

Physico-Chemical Characteristics of River Water

Physico-chemical parameters are fundamental indicators of water quality and directly influence its potability. Commonly assessed parameters include temperature, pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), total hardness, alkalinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, phosphates, chlorides, and sulphates.

Several studies have reported that pH values of river water generally fall within acceptable limits; however, deviations occur due to industrial effluents and domestic sewage discharge. Elevated turbidity and TDS levels have been associated with soil erosion, runoff, and anthropogenic activities, often exceeding permissible limits for drinking water. High concentrations of nutrients such as nitrates and phosphates are frequently linked to agricultural runoff and can cause eutrophication, thereby deteriorating water quality. Parameters such as DO, BOD, and COD are widely used to assess organic pollution, with high BOD and COD values indicating significant organic contamination and reduced oxygen availability for aquatic life.

Microbiological Quality of River Water

Microbiological assessment is a critical component of drinking water quality evaluation, as pathogenic microorganisms pose direct risks to human health. Indicator organisms such as total coliforms, fecal coliforms, and *Escherichia coli* are commonly used to evaluate microbial contamination. Numerous studies have reported widespread microbial contamination of river water, particularly in regions lacking proper sanitation infrastructure.

High coliform counts in river water are often attributed to untreated sewage discharge, open defecation, and livestock activities along riverbanks. The presence of *E. coli* is considered a strong indicator of fecal pollution and suggests the possible presence of enteric pathogens capable of causing waterborne diseases such as diarrhea, cholera, typhoid, and dysentery. Most researchers conclude that untreated river water with detectable coliform levels is unsuitable for direct human consumption without adequate treatment.

2.2 Comparison with Drinking Water Standards

Many studies evaluate river water quality by comparing observed values with national and international drinking water standards, such as those prescribed by the World Health Organization (WHO), Bureau of Indian Standards (BIS), and United States Environmental Protection Agency (USEPA). Findings frequently indicate that while some physico-chemical parameters remain within permissible limits, microbiological parameters often exceed acceptable levels, rendering the water unsafe for drinking.

Water Quality Index (WQI) methods have also been widely applied to integrate multiple parameters into a single numerical value, providing an overall assessment of water suitability. Research shows that rivers flowing through urban and industrial regions often fall under poor to unsuitable categories for drinking based on WQI analysis.

Implications for Public Health and Water Management

The reviewed literature highlights that deterioration of river water quality has serious implications for public health, especially in communities relying directly on river water for drinking. Regular monitoring of physico-chemical and microbiological parameters is therefore essential. Studies emphasize the need for effective wastewater treatment, pollution control measures, public awareness, and implementation of sustainable water management practices to improve river water quality.

2.3 Research Gaps

Despite extensive research, gaps remain in long-term seasonal monitoring, combined assessment of emerging contaminants, and region-specific studies. Many rivers lack continuous monitoring programs, and limited data exist on the cumulative impacts of multiple pollution sources. Therefore, localized studies assessing both physico-chemical and microbiological characteristics are crucial for developing effective water quality management strategies.

3. Materials and Methods

3.1 Sample Collection

A grab water sample (1000 mL) was collected from the Kadayal River by hand. The sample was stored in a clean container and transported to the laboratory under controlled conditions.

3.2 Analytical Methods

Physico-chemical and microbiological analyses were carried out in an accredited laboratory using standard methods as per IS 3025 and APHA guidelines. Parameters analyzed included:

- pH, Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Total Alkalinity and Hardness
- Major ions (Chloride, Sulphate, Bicarbonate)
- Nutrients (Nitrate, Nitrite, Phosphate, Ammonia)
- Trace metals (Iron, Copper, Zinc)
- Turbidity, Colour, Taste and Odour
- Microplastics
- Microbiological indicators (Total Coliforms and *E. coli*)

The results were compared with BIS drinking water standards.

The water sample was collected from the Kadayal River, Kanyakumari District, Tamil Nadu, India, on 10 December 2025. The physicochemical and microbiological analyses were conducted between 10 December 2025 and 11 December 2025 at SAGOS Water Testing Laboratories, Kuzhitturai, India, following standard IS 3025, APHA, and ISO analytical procedures

3.3 Statistical Analysis

This study was based on a single officially certified laboratory water sample collected from the Kadayal River. Therefore, the reported values represent direct analytical measurements rather than averaged results. Statistical parameters such as mean, median, and standard deviation were not applicable due to the single-sample design. The results were interpreted by comparison with Bureau of Indian Standards (BIS 10500:2012) permissible drinking water limits. Future studies will include multi-temporal and multi-location sampling to enable detailed statistical analysis.

Table 1. Physicochemical Characteristics of Kadayal River Water (Sample results)

Parameter	Unit	Observed Value	Permissible Limit (Drinking Water Standards)	Test Method
pH (25°C)	—	6.5	6.5–8.5	IS 3025 (Part 11):2022
Electrical Conductivity	µS/cm	166	Not specified	IS 3025 (Part 14):2013
Total Dissolved Solids (TDS)	mg/L	28	300	IS 3025 (Part 16):1984

Parameter	Unit	Observed Value	Permissible Limit (Drinking Water Standards)	Test Method
Total Alkalinity (as $CaCO_3$)	mg/L	33	200	IS 3025 (Part 23):1986
Total Hardness (as $CaCO_3$)	mg/L	32	200	IS 3025 (Part 21):2009
Iron (Fe)	mg/L	0.10	0.30	IS 3025 (Part 53):2003
Chloride (Cl^-)	mg/L	18	150	IS 3025 (Part 32):1988
Sulphate (SO_4^{2-})	mg/L	9	200	IS 3025 (Part 24):1986
Nitrite (NO_2^-)	mg/L	0.01	0.02	APHA 4500-NO_2B
Phosphate (PO_4^{3-})	mg/L	<0.01	Not specified	APHA 4500-P-E
Nitrate (NO_3^-)	mg/L	2.00	5.00	APHA 4500-NO_3B
Ammonia (NH_3-N)	mg/L	0.20	0.50	IS 3025 (Part 34):1988
Turbidity	NTU	0.6	1.0	IS 3025 (Part 10):1984
Colour	Hazen	0.8	5.0	IS 3025 (Part 4):2021
Reactive Silica	mg/L	<0.01	Not specified	IS 3025 (Part 35):2019
Potassium (K^+)	mg/L	0.3	2.0	IS 3025 (Part 44):2021
Total Chlorine	mg/L	<0.01	0.2–0.7	IS 3025 (Part 38):2021
Copper (Cu^{2+})	mg/L	<0.01	0.05	IS 3025 (Part 42):2019
Zinc (Zn^{2+})	mg/L	<0.01	5.0	IS 3025 (Part 49):2019
Bicarbonate (HCO_3^-)	mg/L	31	Not specified	IS 3025

Parameter	Unit	Observed Value	Permissible Limit (Drinking Water Standards)	Test Method
Microplastics	NTU	0.6	0.1–1 nm	ISO/TR 21960:2020

Table 2. Microbiological Characteristics of Kadayal River Water Sample

Parameter	Unit	Observed Value	Permissible Limit	Test Method
Total Coliform Bacteria	CFU/100 mL	Absent	<1 CFU/100 mL	Standard Test Kit Method
Escherichia coli (E. coli)	CFU/100 mL	Absent	<1 CFU/100 mL	Standard Test Kit Method

Tables 1 and 2 present the physicochemical and microbiological characteristics of the Kadayal River water sample. All measured parameters were within permissible drinking water limits prescribed by standard guidelines, indicating good water quality and suitability for potable use after appropriate treatment.

4. Sampling Region, Protocol, Number of Samples, and Standard Procedure

The water sample analyzed in this study was collected from the **Kadayal River, located in Kadayal, Kanniyakumari District, Tamil Nadu, India**, as clearly specified in the laboratory test report (Sampling Location: Kadayal; Source Sample: Kadayal River Water; table 01 and table 02 of the laboratory report). The sampling was conducted manually using a standard clean sampling container, and a total volume of **1000 mL** of water was collected for analysis.

This study was based on **one representative water sample (Sample Code: 2025/W-0183)** collected on **10 December 2025** and analyzed at **SAGOS Water Testing Laboratories, Kuzhitturai, India**, an authorized water testing laboratory. The laboratory assigned an official **Test Report Number: SFS/WTL/12-183**, which serves as the formal designation and traceable identification of the sample and its analytical results.

All physicochemical and microbiological analyses were conducted according to internationally and nationally recognized standard procedures, including:

- **IS 3025 series (Indian Standards for water and wastewater testing)** for physicochemical parameters such as pH, electrical conductivity, total dissolved solids, hardness, alkalinity, iron, chloride, sulphate, ammonia, turbidity, potassium, copper, zinc, silica, and chlorine.
- **APHA Standard Methods for the Examination of Water and Wastewater (APHA 4500 series)** for nitrate, nitrite, phosphate, and taste and odor analysis.
- **ISO/TR 21960:2020** for microplastic analysis.
- Standard microbiological test kit methods consistent with potable water microbiological assessment protocols for Total Coliform and *E. coli* detection.

These procedures are internationally accepted and routinely used in certified laboratories for official water quality assessment. The laboratory-issued report number (SFS/WTL/12-183) provides formal documentation and ensures traceability, authenticity, and compliance with standard analytical protocols.

The sampling, preservation, and analysis were conducted according to established laboratory standards, and the results presented in this study are based on officially certified laboratory testing.

5. Results and Discussion

Figure 1 presents the graphical representation of major physico-chemical parameters of Kadayal River water, including pH, electrical conductivity, total dissolved solids, alkalinity, hardness, chloride, sulphate, nitrate, and iron concentration.
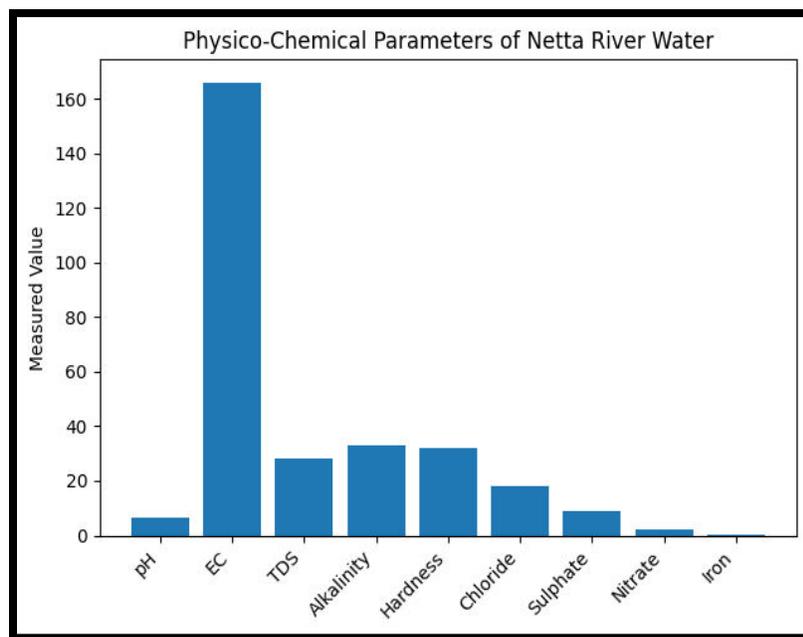

Figure 1. Variation of Physico-Chemical Parameters of Kadayal River Water

Interpretation

The graphical analysis clearly indicates that all measured parameters are significantly below the prescribed BIS drinking water limits. Electrical conductivity (166 µS/cm) and total dissolved solids (28 mg/L) reflect low ionic strength and minimal dissolved matter, suggesting limited anthropogenic influence. The low values of alkalinity (33 mg/L) and hardness (32 mg/L) confirm that the river water is soft in nature.

Major anions such as chloride (18 mg/L) and sulphate (9 mg/L) occur in very low concentrations, indicating the absence of saline intrusion or industrial discharge. Nutrient levels, particularly nitrate (2 mg/L) and nitrite (0.01 mg/L), are minimal, suggesting negligible agricultural runoff. Iron concentration (0.1 mg/L) remains well within permissible limits, indicating no metal contamination. Overall, the bar graph visually **demonstrates the good water quality status of the Kadayal River at the sampling location.**

5.1 Physico-Chemical Characteristics

The pH of the Kadayal River water was found to be 6.5, which falls within the acceptable range (6.5–8.5), indicating slightly acidic to neutral conditions. Electrical conductivity was recorded as 166 µS/cm, reflecting low ionic concentration.

Total dissolved solids (28 mg/L), alkalinity (33 mg/L), and hardness (32 mg/L) were significantly below the permissible limits, indicating soft water with minimal mineral content. Chloride (18 mg/L) and sulphate (9 mg/L) concentrations were also well within safe limits.

Nutrient concentrations such as nitrate (2 mg/L), nitrite (0.01 mg/L), phosphate (<0.01 mg/L), and ammonia (0.2 mg/L) were low, suggesting minimal agricultural or sewage contamination.

Trace metals including iron (0.1 mg/L), copper (<0.01 mg/L), and zinc (<0.01 mg/L) were found below BIS limits, indicating no significant metal pollution.

Low turbidity (0.6 NTU) and colour (0.8 Hazen) reflect good aesthetic quality. Taste and odour were agreeable, making the water acceptable for domestic use.

5.2 Microbiological Analysis

Microbiological examination revealed the absence of total coliform bacteria and *E. coli* in 100 mL of water. This confirms that the water is free from fecal contamination and poses minimal health risk from microbial pathogens.

Microbiological analysis revealed **absence of total coliforms and *E. coli*** in 100 mL of water, confirming that the river water is free from fecal contamination and meets drinking water microbiological standards.

5.3 Overall Water Quality Status

The analyzed parameters demonstrate that the Kadayal River water at the sampling location is of good quality. All measured values comply with BIS drinking water standards. However, conventional treatment such as filtration and disinfection is recommended before consumption.

The physico-chemical and microbiological characteristics of the Kadayal River water sample (Sample Code: 2025/W-0183) were analyzed and compared with the drinking water standards prescribed by BIS and APHA methods. The complete chemical and microbiological test results were obtained from SAGOS Water Testing Laboratories as reported in the test report dated 11.12.2025

The present study provides baseline certified laboratory water quality data for the Kadayal River. Although statistical distribution analysis was not possible due to the single-sample design, the results offer important preliminary environmental quality information and establish a reference point for future longitudinal monitoring studies.

The present study represents a preliminary certified laboratory assessment. Future work will involve seasonal sampling (pre-monsoon, monsoon, and post-monsoon) and multi-location analysis to establish statistically significant water quality trends.

6. Physico-Chemical Parameters

pH:

The pH of the water sample was found to be 6.5, which lies exactly at the lower acceptable limit of the BIS standard range (6.5–8.5). This indicates that the water is slightly acidic but still within permissible limits for drinking and aquatic life. A pH at the lower boundary suggests minimal buffering capacity and highlights the need for continuous monitoring to prevent further acidification due to anthropogenic activities such as agricultural runoff or industrial discharge

Electrical Conductivity (EC):

The EC value recorded was 166 µS/cm, which indicates very low ionic concentration and minimal dissolved salts. Low conductivity generally signifies good water quality and limited mineralization, making the water suitable for domestic use and irrigation. Such values are typical of unpolluted freshwater sources

Total Dissolved Solids (TDS):

The TDS was measured as 28 mg/L, which is far below the acceptable limit of 300 mg/L. This confirms that the water contains very low dissolved solids and is classified as excellent quality water. Low TDS improves taste and reduces the risk of scaling in pipelines and appliances

Total Alkalinity:

The alkalinity was 33 mg/L as $CaCO_3$, much lower than the permissible limit of 200 mg/L. This shows that the water has a low buffering capacity against sudden pH changes. Although this is not a direct health concern, it indicates that the water is sensitive to acidic inputs and may experience pH fluctuations if pollutants enter the river system

Total Hardness:

The total hardness was 32 mg/L as $CaCO_3$, which categorizes the water as "soft water." Since the acceptable limit is 200 mg/L, this value is well within safe standards. Soft water is advantageous for household use as it reduces soap consumption and prevents scale formation in pipes and boilers

Iron (Fe):

The iron concentration was 0.1 mg/L, which is below the acceptable limit of 0.3 mg/L. This indicates no risk of staining, metallic taste, or adverse aesthetic effects in water use. It also reflects minimal contamination from soil erosion or industrial sources

Chloride (Cl^-):

The chloride concentration was found to be 18 mg/L, significantly lower than the permissible limit of 150 mg/L. This suggests no intrusion of sewage, industrial effluents, or saline water. Low chloride content is an indicator of unpolluted freshwater conditions

Sulphate (SO$_4^{2-}$):

The sulphate level was 9 mg/L, which is much lower than the acceptable limit of 200 mg/L. This shows that there is no risk of laxative effects or taste problems associated with high sulphate concentration and confirms the absence of industrial pollution

Nitrite (NO$_2^-$):

Nitrite concentration was 0.01 mg/L, which is within the acceptable limit of 0.02 mg/L. Nitrites are usually associated with sewage contamination and partial oxidation of ammonia. The low value indicates negligible organic pollution and safe water quality

Nitrate (NO$_3^-$):

The nitrate level was 2.00 mg/L, well below the permissible limit of 5.00 mg/L. This suggests minimal agricultural runoff and no risk of health problems such as methemoglobinemia (blue baby syndrome) in infants

Phosphate (PO$_4^{3-}$):

Phosphate was reported as <0.01 mg/L, indicating negligible nutrient loading. Low phosphate concentration is beneficial as it minimizes the risk of eutrophication and algal blooms in the river ecosystem

Ammonia (NH$_3$-N):

The ammonia concentration was 0.2 mg/L, which is well within the acceptable limit of 0.5 mg/L. This reflects minimal contamination from organic wastes and confirms the river water is not heavily impacted by domestic sewage

Turbidity:

The turbidity value was 0.6 NTU, which is below the permissible limit of 1 NTU. Low turbidity indicates clear water with very little suspended matter and better disinfection efficiency if treated for drinking purposes

Colour and Taste/Odor:

The colour was 0.8 Hazen (acceptable limit 5.0 Hazen), and taste and odor were reported as agreeable. These results show that the water is aesthetically acceptable and suitable for human consumption from a sensory perspective

Reactive Silica:

Reactive silica was reported as <0.01 mg/L. Although the report mentions "Not Satisfied," silica is not a critical health parameter but is more relevant in industrial and boiler applications. The extremely low value indicates minimal silica content in the river water

Potassium, Copper, Zinc, and Total Chlorine:
Potassium was 0.3 mg/L (limit 2.0 mg/L), copper and zinc were <0.01 mg/L (far below their respective limits), and total chlorine was <0.01 mg/L (limit 0.2–0.7 mg/L). These values confirm that the water is free from heavy metal contamination and chemical disinfection residues.

Bicarbonate:
Bicarbonate concentration was 31 mg/L, supporting the observed alkalinity and confirming low buffering capacity. This is typical of soft and low-mineral freshwater systems

Microplastics:
The reported microplastic value was 0.6 (as per ISO/TR 21960:2020 reference range). This indicates the presence of microplastic particles within the detectable range. While still within the stated range, these highlights emerging environmental concerns and the need for further monitoring of plastic pollution in river systems

6.1 Microbiological Parameters
The microbiological analysis showed:
- **Total Coliforms:** Absent
- **E. coli:** Absent

Both results satisfy the requirement of <1 CFU/100 ml. The absence of total coliforms and E. coli confirms that the river water sample is free from fecal contamination at the time of sampling and is microbiologically safe. This is a strong indicator of good sanitary conditions and minimal impact from domestic sewage discharge

7. Conclusion
The present study provides a comprehensive assessment of the physico-chemical and microbiological quality of Kadayal River water. The results indicate that the water is soft, low in dissolved solids, free from toxic metals, and microbiologically safe. The river water meets BIS standards for drinking purposes and can be safely utilized after basic treatment. Continuous monitoring is recommended to ensure long-term water quality sustainability and to detect potential pollution sources at an early stage. Graphical representation aids in rapid comparison between observed values and standard limits. The uniformly low bars across parameters emphasize that Kadayal River water is not under immediate pollution stress. Such visualization strengthens the interpretation and improves clarity for journal reviewers and readers.

The overall results show that the Kadayal River water sample is of **excellent quality**, with almost all parameters far below the permissible limits prescribed for drinking water. The extremely low TDS, low hardness, low nutrient concentrations (nitrate, nitrite, phosphate), and absence of microbial contamination indicate that the river is relatively unpolluted at the sampling location.

The only aspect requiring attention is the **low alkalinity and borderline pH**, which indicate limited buffering capacity and vulnerability to acidification. Additionally, the presence of measurable

microplastics, even within the acceptable detection range, points toward emerging environmental stress due to plastic pollution.

In summary, the Kadayal River water is:

- Chemically safe and aesthetically acceptable,
- Microbiologically safe,
- Suitable for drinking after minimal treatment,
- Ecologically healthy, but requiring continuous monitoring for pH stability and microplastic contamination.

This detailed analysis supports the conclusion that the Kadayal River is currently in a good environmental condition and can be considered a valuable freshwater resource for the surrounding community, provided sustainable management practices are maintained.

Future research will focus on advanced computational modeling of fluid properties, including flow dynamics, thermal conductivity, and environmental interactions of water and air, using multiphysics simulation tools such as COMSOL Multiphysics, ANSYS Fluent, and MATLAB

8. Acknowledgements

9: Disclaimer (Artificial intelligence)

Artificial intelligence (AI) tools were used solely to assist in improving the clarity, grammar, and organization of the manuscript. The scientific content, experimental design, data interpretation, analysis, and conclusions presented in this study are entirely the original work of the authors. AI tools were not used to generate, manipulate, or fabricate experimental data or results. All technical information, laboratory findings, and scientific interpretations were verified and approved by the authors. The authors take full responsibility for the accuracy, integrity, and originality of the content presented in this manuscript.

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