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Research Article

Physico-Chemical and Microbiological Assessment of Domestic Water Samples in Barangay Ferdinand, Marcos, Ilocos Norte

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Abstract

This study assessed the physico-chemical and microbiological quality of domestic water sources in Barangay Ferdinand, Marcos, Ilocos Norte, to generate evidence for water safety and public health interventions. A descriptive cross-sectional design was employed, involving the collection of five water samples from commonly used household sources, consisting of three deep wells and two developed springs. Laboratory analyses were conducted at a Department of Health-accredited facility in accordance with the Philippine National Standards for Drinking Water (PNSDW, 2017). Physico-chemical parameters evaluated included temperature, pH, turbidity, total dissolved solids (TDS), hardness, major ions, and selected inorganic contaminants, while microbiological assessment focused on total coliforms and *Escherichia coli* using standard bacteriological methods. Results showed that all water samples generally complied with PNSDW limits for physico-chemical parameters, except for one deep-well sample that exhibited a slightly acidic pH (6.3). However, microbiological analysis revealed that all five samples tested positive for total coliforms and *E. coli*, with Most Probable Number (MPN) values exceeding allowable limits for potable water. These findings indicate a marked contrast between chemical acceptability and microbiological safety of the water sources. The study concludes that although domestic water sources in Barangay Ferdinand are chemically suitable for household use, none are safe for direct consumption without treatment due to fecal contamination. Immediate household-level disinfection, routine microbiological monitoring, and community-based sanitation interventions are strongly recommended to reduce the risk of waterborne diseases and improve water safety.

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1. Introduction

Safe water is a basic human necessity essential for ensuring health and overall well-being, underscoring the importance of maintaining adequate water quality. According to the World Health Organization (WHO), nearly 2.2 billion people worldwide lacked access to safely managed drinking water in 2019, highlighting the urgent need for regular monitoring and management of water sources to prevent health risks. Water from natural sources and groundwater is particularly vulnerable to contamination due to both natural processes and human activities such as agriculture, industrialization, and improper waste disposal. These risks are more pronounced in rural barangays, including Barangay Ferdinand, Marcos, Ilocos Norte, where communities often rely on untreated domestic water sources (United Nations Environment Programme, 2016).

In the Philippines, drinking water safety is regulated under the Philippine National Standards for Drinking Water (PNSDW), which establish acceptable physico-chemical and microbiological parameters to protect public health. According to the Department of Health (DOH, 2017), deviations from these standards may lead to waterborne diseases such as cholera, amoebiasis, and shigellosis. These health risks emphasize the importance of comprehensive water quality testing, particularly in communities without access to centralized water treatment facilities. Although Sustainable Development Goal 6 (SDG 6) aims to ensure the availability and sustainable management of water and sanitation for all, many rural areas in the Philippines remain far from achieving this target due to limited infrastructure and insufficient monitoring of water quality monitoring.

The Philippines is also among the countries most vulnerable to climate change, with increased rainfall and flooding contributing to water degradation (Environmental Management

Bureau, 2021). When combined with agricultural runoff, inadequate waste disposal practices, and aging water infrastructure, these conditions significantly increase the risk of water contamination in rural settings. While numerous studies have examined water quality in urban areas and large-scale water systems (Ali et al., 2017; WHO, 2017), rural communities remain underrepresented in existing literature. Most available studies present findings at the regional or provincial level, often overlooking the localized environmental, infrastructural, and social conditions that directly influence barangay-level water sources.

Despite existing regional and provincial water quality studies in the Philippines, barangay-level assessments that integrate both physico-chemical and microbiological parameters remain limited. In particular, rural communities relying on Level I and Level II water systems are underrepresented in empirical water research safety research. Moreover, while physico-chemical testing is commonly conducted, fewer studies simultaneously assess microbiological quality alongside environmental and sanitation-related factors such as proximity to agricultural areas, waste disposal systems, and seasonal variation (APHA, 2017). An additional gap exists in understanding how community practices and sanitation behaviors may influence water contamination and related health risks. Without such localized and integrated data, public health interventions may be inadequately targeted or ineffective.

Barangay Ferdinand, Marcos, Ilocos Norte, has not yet been the focus of a comprehensive study assessing domestic water quality using both physico-chemical and microbiological parameters. The barangay primarily depends on Level I and Level II water systems, as classified by the Local Government Unit (LGU) of Marcos. Level I systems include covered wells and developed springs intended for individual households, while Level II systems consist of

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communal faucets serving multiple households. Despite the presence of these systems, only 18.04% of households have access to safe drinking water from a community system or developed spring, while approximately 86.66% rely on deep wells. Deteriorating pipeline infrastructure and the lack of regular system rehabilitation further compromise the safety and reliability of water sources.

This study addresses the identified research gap by providing localized, laboratory-verified evidence on the physico-chemical and microbiological quality of domestic water sources in Barangay Ferdinand, Marcos, Ilocos Norte. Specifically, it evaluates key parameters such as pH, turbidity, total dissolved solids, total coliforms, and *Escherichia coli*, while considering potential anthropogenic and environmental sources of contamination, including agricultural activities and sanitation conditions. These findings aim to provide scientific evidence to guide local government units, policymakers, and health agencies in improving quality management and implementing targeted public health and sanitation interventions.

2. Materials and Methods

2.1 Locale of the Study

The study was conducted in Barangay Ferdinand, Marcos, Ilocos Norte, a progressive community within the municipality known for its agricultural landscape and emerging economy, which relies heavily on domestic water sources for daily needs. The Municipality of Marcos is in the Southeastern part of the Province of Ilocos Norte in Region I, approximately lying 12° 45' to 12° 50' longitude and 18°05' to 18° 07' latitude.

It is bounded on the north by the Municipality of Dingras; on the South by the Municipality of Nueva Era and the Province of Abra; on the Southwest by the Municipality of Banna (Espiritu); on the east by the Province of Apayao; and on the west by the Municipality of

Research Questions

Generally, this study aimed to analyze the physico-chemical and microbiological characteristics of water samples in Barangay Ferdinand Marcos, Ilocos Norte.

Specifically, it aimed to answer the following questions:

1. What are the different sources of water in Barangay Ferdinand, Marcos?
2. What procedures are used to collect water samples from the identified sources?
3. What physico-chemical and microbiological tests will be performed on the water samples?
4. Based on the test results, what are the potential health risks, such as waterborne diseases and gastrointestinal illnesses, associated with the water sources?
5. What solutions can be implemented to ensure water safety based on the findings discussed in the study?

Sarrat. Barangay Ferdinand is primarily agricultural, and the quality of water is crucial for drinking. The community is actively engaged in discussions about water safety and management, making it a relevant site for this research.

The water testing for this study was conducted at the Ilocos Norte Water District (INWD) facility located in Brgy. 22 Ermita Hill, Laoag City, Ilocos Norte. It is accredited by DOH No. 01-0002-2325-LW-1. This testing location is central to monitoring and managing water resources in the region, and the data gathered at these sites is essential for understanding water quality and its implications for public health. The water tests were performed at their

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designated testing sites, ensuring the collection of accurate and reliable data for the study.

2.2 Data Gathering Procedure

Water samples for physico-chemical analysis were collected in sterile 4-6-liter containers from each selected water source. Containers were sealed with plastic covers and properly labeled with date, time, and sampling location. For microbiological analysis, 500mL water samples were collected using sterile bottles and similarly labeled.

Immediately after collection, all samples were placed in an insulated cooler to preserve sample integrity and prevent microbial proliferation during transport. Samples were transported to the Ilocos Norte Water District (INWD) laboratory within six (6) hours of collection, in accordance with standard water sampling protocols.

2.3 Sampling Procedure

In this study, the sample size was determined based on feasibility, laboratory capacity, and representativeness of the primary water sources used in the barangay, consistent with similar rural water quality studies. A purposive sampling technique was used to select five domestic water sources within the barangay. These sources included deep well and developed spring systems that are regularly used by residents for household activities. Selection was based on accessibility, frequency of use, and perceived importance to the community, ensuring that the samples were representative of the barangay's primary water supply while remaining feasible within the study's time and resource constraints (Etikan et al., 2016). All samples were transported to the Ilocos Norte Water District (INWD), a Department of Health-accredited laboratory, for standardized physico-chemical and microbiological analysis.

2.4 Data Gathering Instrument

Laboratory analysis served as the primary data-gathering instrument in this study. Water samples from the identified wells and spring

sources across the barangay were analyzed following the Philippine National Standards for Drinking Water (PNSDW), as mandated under Department of Health Administrative Order No. 2017-0010.

Physico-chemical parameters analyzed included temperature, pH, turbidity, total dissolved solids, hardness, and selected inorganic substances. Microbiological analysis focused on the detection of total coliforms and *Escherichia coli*, which are critical indicators of fecal contamination and water safety.

Based on PNSDW guidelines and INWD laboratory protocols, bacteriological analyses such as the Multiple Tube Fermentation Technique (MTFT) and Heterotrophic Plate Count (HPC) typically required 24–48 hours for presumptive results and an additional 24–48 hours for confirmed results. Physico-chemical analyses were completed within 5–7 days following sample collection.

2.5 Data Analysis

Data analysis focused on two main components: physico-chemical and microbiological parameters. Physico-chemical analysis involved the evaluation of parameters such as pH, turbidity, temperature, total dissolved solids, and the presence of selected chemical constituents. Microbiological analysis assessed the presence of total coliforms and *Escherichia coli*, which serve as key indicators of potential health risks.

The Ilocos Norte Water District played a central role in conducting laboratory analyses in accordance with PNSDW standards, ensuring the accuracy and credibility of results. The researchers then interpreted the laboratory findings by comparing them against established national drinking water standards to identify compliance and potential health concerns.

Based on the interpreted results, the study assessed potential public health implications and formulated evidence-based sanitation and water

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safety recommendations specifically tailored to Barangay Ferdinand, Marcos, Ilocos Norte.

2.6 Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the sample size was limited to five domestic water sources, comprising two developed springs and three deep wells. While these sources represent the primary water systems used by residents in Barangay Ferdinand, the small number of samples limits the generalizability of the results to other water sources within the barangay or to other rural communities.

Second, water sampling was conducted at a single point in time. Seasonal variations, particularly during periods of heavy rainfall or prolonged dry seasons, were not captured. Such variations may influence both physico-chemical characteristics and microbial contamination levels due to changes in surface runoff, groundwater recharge, and sanitation conditions. Future studies incorporating multi-season or

longitudinal sampling would provide a more comprehensive assessment of water quality dynamics.

Third, the study focused exclusively on selected physico-chemical and microbiological parameters in accordance with the Philippine National Standards for Drinking Water (PNSDW, 2017). Other potential contaminants, including emerging pollutants, pesticides, and additional microbial pathogens, were not analyzed and may present additional health risks.

Finally, the study did not quantitatively assess surrounding environmental and sanitation factors, such as exact distances from septic systems, agricultural activity intensity, or well construction integrity, which may have contributed to microbial contamination. Despite these limitations, the study provides valuable baseline, laboratory-verified evidence of water quality conditions in Barangay Ferdinand and highlights critical public health risks that warrant immediate intervention.

3. Results and Discussion

3.1 Sources and Distribution of Domestic Water Samples

Five domestic water samples were collected from Barangay Ferdinand, Marcos, Ilocos Norte, representing the primary household water sources used by residents. These included two

developed springs (DS1 from Sitio 1 and DS2 from Sitio 3) and three deep wells (DW3, DW4, and DW5, all located in Sitio 3).

Table 1. The water samples collected from Barangay Ferdinand, Marcos, Ilocos Norte.

Domestic Water Samples	Type of Samples	Site of Collection
Domestic Water A	DS1 (developed spring)	Sitio 1
Domestic Water B	DS2 (developed spring)	Sitio 3
Domestic Water C	DW3 (deep well)	Sitio 3
Domestic Water D	DW4 (deep well)	Sitio 3
Domestic Water E	DW5 (deep well)	Sitio 3

All sampled sources are classified as Level I water systems, which are typically unchlorinated and rely on natural protection mechanisms. The concentration of sampled sources in Sitio 3

reflects the barangay's reliance on groundwater systems in this area, underscoring the importance of assessing both chemical and microbiological safety at the household level.

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3.2 Physico-Chemical Water Quality Across Sources

The physicochemical characteristics of the five (5) collected water samples from different sitios in Brgy. Ferdinand, Marcos, Ilocos Norte were analyzed. The physicochemical parameters were

limited to the temperature, turbidity, color, odor, total dissolved solids, calcium, magnesium, pH, specific conductance, alkalinity, hardness, chlorine residual, acidity, carbonate, bicarbonate, chloride, nitrate, phosphate, sulfate, iron, and manganese.

Table 2. The physico-chemical characteristics of the water samples and the maximum allowable levels.

Parameter	DS1	DS2	DW3	DW4	DW5	Max. Allowable Level
I. Acceptability Aspects						
Temperature, °C	27	27	27	27	27	none
Turbidity, NTU	1	nil	nil	nil	nil	5
Color (Apparent), Color Units	3	nil	nil	nil	nil	10
Odor	Unobjecti onable	Unobjecti onable	Unobjecti onable	Unobjecti onable	Unobjecti onable	Unobjectionable
pH at 25 °C	8.0	8.0	6.8	6.3	6.7	6.5-8.5
Specific Conductance, µS/cm	298	298	244	132	198	none
Total Dissolved Solids, TDS, mg/L	149	149	122	66	99	600
Acidity, mg/L CaCO ₃	nil	nil	6	8	6	none
Alkalinity, mg/L CaCO ₃	120	88	86	48	66	none
Carbonate, mg/L	19	10	nil	nil	nil	none
Bicarbonate, mg/L	107	88	105	59	81	none

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Chloride, mg/L	9	9	10	10	10	250
Total Hardness, mg/L CaCO₃	78	66	60	22	36	300
Calcium, mg/L	19	18	24	9	14	none
Magnesium, mg/L	7	5	nil	nil	nil	none
Phosphate, mg/L	0.57	0.21	0.19	0.09	0.11	none
Sulfate, mg/L	17	56	19	5	14	250
Iron, mg/L	nil	0.02	0.09	0.06	0.07	1.0
II. Inorganic Chemicals						
Nitrate, mg/L	1.9	1.8	5.5	3.7	6.2	50.00
Manganese, mg/L	nil	nil	nil	nil	nil	1.0
Arsenic, mg/L	n.a.	n.a.	n.a.	n.a.	n.a.	0.01
Cadmium, mg/L	n.a.	n.a.	n.a.	n.a.	n.a.	0.003
Lead, mg/L	n.a.	n.a.	n.a.	n.a.	n.a.	0.01
III. Treatment Chemical Used						
Chlorine Residual, mg/L	nil	nil	nil	nil	nil	0.3-1.5

Across all five sampling sites, physico-chemical parameters generally complied with the Philippine National Standards for Drinking Water (PNSDW, 2017), indicating that the water sources were chemically acceptable for domestic use. Temperature values were uniform at 27 °C, consistent with natural groundwater conditions in tropical environments. Turbidity, color, and odor were within acceptable limits for all

samples, reflecting good aesthetic quality and low suspended solids. The pH values for four of the five samples (DS1, DS2, DW3, and DW5) fell within the acceptable range of 6.5–8.5. One deep well sample (DW4) exhibited a slightly acidic pH of 6.3, marginally below the standard. While this deviation is minor, prolonged consumption of slightly acidic water may contribute to pipe corrosion and leaching of

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metals over time. Total dissolved solids (TDS), alkalinity, hardness, calcium, magnesium, chloride, sulfate, nitrate, iron, and manganese levels were all well below maximum allowable limits, classifying the water as soft to moderately hard and chemically safe for household activities.

Notably, no residual chlorine was detected in any of the samples. The absence of chlorine

3.3 Microbiological Quality and Public Health Implications

The bacteriological characteristics of the five (5) collected domestic water samples from different

indicates that none of the water sources had undergone disinfection, a common condition for Level I water systems in rural communities (Lombay et al., 2017). While physico-chemical compliance suggests acceptable mineral composition and aesthetic quality, the lack of residual disinfectant increases vulnerability to microbial contamination, particularly in environments exposed to surface runoff or nearby sanitation systems.

sitios in Brgy. Ferdinand, Marcos, Ilocos Norte were tested. The microbiological parameters were limited to the multiple tube fermentation technique and the heterotrophic plate count.

Table 3. The microbiological characteristics of the water samples and the standard values.

	DS1	DS2	DW3	DW4	DW5	STANDARD VALUES
I. Multiple Tube Fermentation Technique (MTFT)						
Total Coliform Test						
No. of Positive Tube/s After 48 Hrs	5	5	5	5	5	0
Most Probable Number (MPN) /100 mL	>8.0	>8.0	>8.0	>8.0	>8.0	<1.1
Thermotolerant Coliform / E. coli Test						
No. of Positive Tube/s After 24 Hrs	5	5	5	5	5	0
Most Probable Number (MPN) /100 mL	>8.0	>8.0	>8.0	>8.0	>8.0	<1.1

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II. Pour Plate Method						
Heterotrophic Plate Count (HPC)						
Colony Forming Units (CFU) /mL	190	130	140	160	150	<500

In contrast to the generally acceptable physico-chemical results, all five water samples failed to meet microbiological standards for drinking water. Total coliforms and *Escherichia coli* were detected in every sample using the Multiple Tube Fermentation Technique, with Most Probable Number (MPN) values exceeding allowable limits (<1.1 MPN/100 mL). These findings unequivocally indicate fecal contamination across both developed springs and deep wells.

Heterotrophic Plate Count (HPC) values ranged from 130 to 190 CFU/mL, remaining below the recommended threshold of 500 CFU/mL. However, acceptable HPC values do not negate the presence of fecal indicator organisms. The consistent detection of *E. coli* across all sites

Comparative Synthesis: Chemical Safety Versus Biological Risk

A clear contrast emerges from the findings, while the water sources in Barangay Ferdinand are chemically acceptable, they are microbiologically unsafe for drinking. This disparity demonstrates that compliance with physico-chemical standards alone does not guarantee potable water. The presence of *E. coli* serves as a strong indicator of fecal pollution and potential exposure to pathogenic microorganisms responsible for waterborne

Implications for Water Safety Management

The findings underscore the urgent need for household-level and community-based interventions to ensure water safety in Barangay Ferdinand. Immediate measures such as boiling, chlorination, or point-of-use filtration are essential to reduce microbial risk. In the longer term, improving well construction standards,

suggests contamination pathways that may include unsealed well linings, proximity of septic systems, inadequate source protection, and the absence of routine disinfection (APHA, 2017; Shittu et al., 2008).

The uniformity of microbiological contamination across different source types highlights a critical pattern: natural filtration processes may effectively regulate dissolved chemical constituents but do not reliably prevent microbial intrusion.

This finding aligns with previous studies in rural Philippine settings, where groundwater sources were chemically compliant yet microbiologically unsafe for consumption (Magwilang et al., 2023; Lomboy et al., 2017).

diseases such as diarrhea, typhoid fever, and cholera (CDC, 2021; WHO, 2022).

The lack of chlorine residual across all samples further exacerbates this risk, as untreated water remains highly susceptible to microbial regrowth and contamination during storage and handling.

These results emphasize the necessity of routine microbiological monitoring alongside chemical testing, particularly in rural barangays dependent on Level I water systems.

protecting spring sources, enhancing sanitation infrastructure, and implementing regular water quality monitoring programs are critical to achieving sustainable access to safe drinking water (United Nations, 2015; WHO, 2021).

Overall, the study demonstrates that while physico-chemical water quality in Barangay

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Ferdinand generally meets national standards, microbiological contamination remains the primary public health concern, necessitating

Compliance with Ethical Standards

In the conduct of the study, the researchers adhered to ethical standards in the collection, analysis, and reporting of data regarding the water quality in Barangay Ferdinand, Marcos, Ilocos Norte.

Respect for Privacy and Anonymity. No personal or household-identifying information was collected or disclosed. All data were anonymized to ensure the privacy of the respondents and communities involved.

Non-Maleficence and Safety. Water sampling was conducted with minimal disruption to household routines and with care to avoid contamination or damage to local sources. Proper procedures were followed to maintain the safety of both researchers and the community.

Environmental Responsibility. The research avoided any form of environmental degradation 6: Clean Water and Sanitation.

Supplementary Details

Supplementary Materials & Data Availability Statement

The data that support the findings of this study are available from the corresponding author, Admirante M. Josue Jr., upon reasonable request.

Author Contributions:

The study was conceptualized by Bayudan, John Philip B.; Juan, Eugene; Gabriel, Joyce J.; Lorenzo, Desiree Kate Anne B.; Pungtilan, Princess Joy A.; Respicio, Ma. Reena M.; Reyes, Princes Hannah M.; Salinas, Sheree Jay C.; and Josue Jr., Admirante M., while the methodology was developed by Bacuyag, Haira; Gabriel, Joyce J.; Lorenzo, Desiree Kate Anne B.; Pungtilan, Princess Joy A.; Respicio, Ma. Reena M.; Reyes, Princes Hannah M.; Salinas,

targeted sanitation and disinfection strategies to prevent waterborne disease.

during sample collection. Sterile materials were used and disposed of responsibly in accordance with health and environmental safety protocols.

Scientific Integrity and Transparency. All findings were reported honestly and without fabrication or misrepresentation. Standardized methods and accredited laboratories (Ilocos Norte Water District) were used to ensure the reliability of the results. Ethical adherence to the Philippine National Standards for Drinking Water (PNSDW) was maintained throughout.

Beneficence and Community Impact. The study aims to benefit the local community by identifying water quality risks and recommending practical improvements.

Results will be shared with local authorities to inform future water sanitation and safety initiatives, aligning with Sustainable Development Goal (SDG)

Sheree Jay C.; and Josue Jr., Admirante M. The investigation, including data and sample collection as well as field or laboratory work, was conducted by Bayudan, John Philip B. and Juan, Eugene. Data curation was managed by Reyes, Princes Hannah M. and Salinas, Sheree Jay C., who, together with Pungtilan, Princess Joy A. and Respicio, Ma. Reena M., also carried out the formal analysis.

Visualization tasks such as preparing tables, figures, and graphs were completed by Gabriel, Joyce J.; Lorenzo, Desiree Kate Anne B.; Pungtilan, Princess Joy A.; Respicio, Ma. Reena M.; Reyes, Princes Hannah M.; and Salinas, Sheree Jay C. The original draft was prepared by Reyes, Princes Hannah M. and Salinas, Sheree Jay C., while review and editing were

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undertaken by Pungtilan, Princess Joy A.; Reyes, Princes Hannah M.; and Salinas, Sheree Jay C. Project administration and supervision were led by Reyes, Princes Hannah M.; Salinas, Sheree Jay C.; and Josue Jr., Admirante M., and funding acquisition was contributed by all authors.

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Institutional Review Board (IRB) Statement

Not applicable.

Informed Consent Statement

Prior to data collection, permission was obtained from the Barangay Captain and households whose water sources were sampled. The purpose, scope, and significance of the research were clearly explained to the Barangay Captain, and consent was secured. Community cooperation was voluntary, and participants retained the right to withdraw at any point.

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Conflicts of Interest

The authors declare no conflict of interest.

Disclosure Statement (Use of AI Tools)

The authors employed Gemini and ChatGPT to assist in structuring the manuscript. All AI-generated suggestions and summaries were rigorously cross-referenced with primary sources and validated by the authors. The final interpretations, conclusions, and data analysis remain the original work of the authors, who assume full accountability for the integrity of the content.

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