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Assessment of the physical and chemical quality of groundwater in developed rural areas: health and environmental issues in the municipality of Koudougou, Burkina Faso

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ABSTRACT

In rural Sahelian territories, groundwater represents the main source of drinking water supply. However, the physicochemical quality of groundwater abstracted from boreholes implemented within rural development projects remains insufficiently documented, even though it is a key factor for the environmental and health sustainability of such investments. This study aims to assess the physicochemical quality of groundwater from two boreholes constructed under the Emergency Territorial Development and Resilience Project (PUDTR) in the municipality of Koudougou, Central-West Burkina Faso, and to analyze their environmental and territorial implications. The methodology is based on water sampling conducted in July 2025 during the rainy season, followed by physicochemical analyses carried out in an accredited laboratory. The analyzed parameters include pH, temperature, turbidity, electrical conductivity, total dissolved solids, major ions, nitrogen compounds, iron, and nutrients. The results were interpreted through comparison with the World Health Organization (WHO) drinking water quality guidelines, combined with a geographical approach integrating environmental context and territorial dynamics. The results indicate that all analyzed parameters comply with WHO guideline values, reflecting good overall groundwater quality. The waters show low mineralization, low nitrate and iron concentrations, and no significant chemical pollution, despite the agricultural context and the active groundwater recharge period. However, the low buffering capacity of the waters

highlights their potential vulnerability to future anthropogenic pressures. These findings provide a valuable baseline for sustainable territorial planning and groundwater management in rural areas benefiting from hydraulic infrastructure projects.

Keywords: Groundwater, Physicochemical water quality, Rural boreholes, Koudougou

1. INTRODUCTION

Access to safe drinking water is a major challenge for sustainable development, particularly in Sahelian countries, where surface water resources are limited and highly dependent on climate variability (Foster and Chilton, 2003; Onda et al., 2012). In these regions, groundwater is the main source of drinking water for rural populations, due to its relative availability and natural protection against certain types of surface pollution (Howard et al., 2006). In Burkina Faso, public policies and rural development projects have largely focused on drilling wells to improve access to drinking water and support local development dynamics (ONEA, 2018; INSD, 2021).

However, while the quantitative availability of water is often highlighted, the physical and chemical quality of groundwater is an issue that is not sufficiently taken into account in land use planning strategies (Jourda et al., 2007; Lapworth et al., 2017). Yet accessible but poor-quality water can be a factor in the health and environmental vulnerability of rural populations. Several studies have shown that borehole water in rural Africa can contain high concentrations of certain chemical elements, such as nitrates, iron and fluoride, or high mineralisation, sometimes exceeding the standards recommended by the World Health Organisation (WHO) (Edmunds and Smedley, 2013; WHO, 2017). These anomalies are often linked to natural factors (lithology, aquifer depth), but also to increasing anthropogenic pressures, such as the intensification of agricultural activities, unplanned land use and inadequate sanitation facilities in rural areas (Gaye and Tindimugaya, 2019).

In integrated rural development projects, such as rural road construction and hydraulic engineering programmes, the environmental dimension is generally addressed from the perspective of visible biophysical impacts, to the detriment of an in-depth analysis of the quality of the water resources used (Bagre et al., 2016). However, the creation of boreholes in changing territories can alter land use, increase traffic around water points and accentuate the risks of qualitative degradation of groundwater (Taylor et al., 2013). In this context, analysing the physical and chemical quality of borehole water is a strategic tool for decision-making in land use planning. It enables the environmental sustainability of water infrastructure and its compatibility with public health objectives to be assessed (Foster et al., 2018).

Environmental geography, which takes an integrated approach to the interactions between societies, resources and territories, provides a relevant framework for understanding these issues at the local level. It is within this perspective that the present study aims to assess the physico-chemical quality of water from two boreholes drilled as part of the Emergency Territorial Development and Resilience Project (PUDTR) in the municipality of Koudougou, located in central-western Burkina Faso. More specifically, the aim is to analyse the compliance of physico-chemical parameters with potability standards, identify the main potential environmental and health risks, and discuss the implications of these results for the sustainable development of rural areas. The central question of this research is therefore: to what extent do

borehole waters drilled as part of rural development projects meet the physico-chemical quality requirements necessary for sustainable territorial development and the protection of the health of local populations?

2. METHOD

2. 1. Study area and Sampling sites

The study was conducted in the municipality of Koudougou (see Figure 1), located in the Central-West region of Burkina Faso. The municipality has experienced extreme rainfall over the last 30 years (Yameogo, 2025). The two villages in the municipality that have benefited from boreholes are located on different soil types. The soil in the village of Toega is hydromorphic, while that of the other village is poor and poorly developed (see Figure 1). This municipality benefits from several territorial development projects aimed at improving rural accessibility and living conditions for the population, in particular through the construction of rural roads and the drilling of wells for drinking water in the villages.

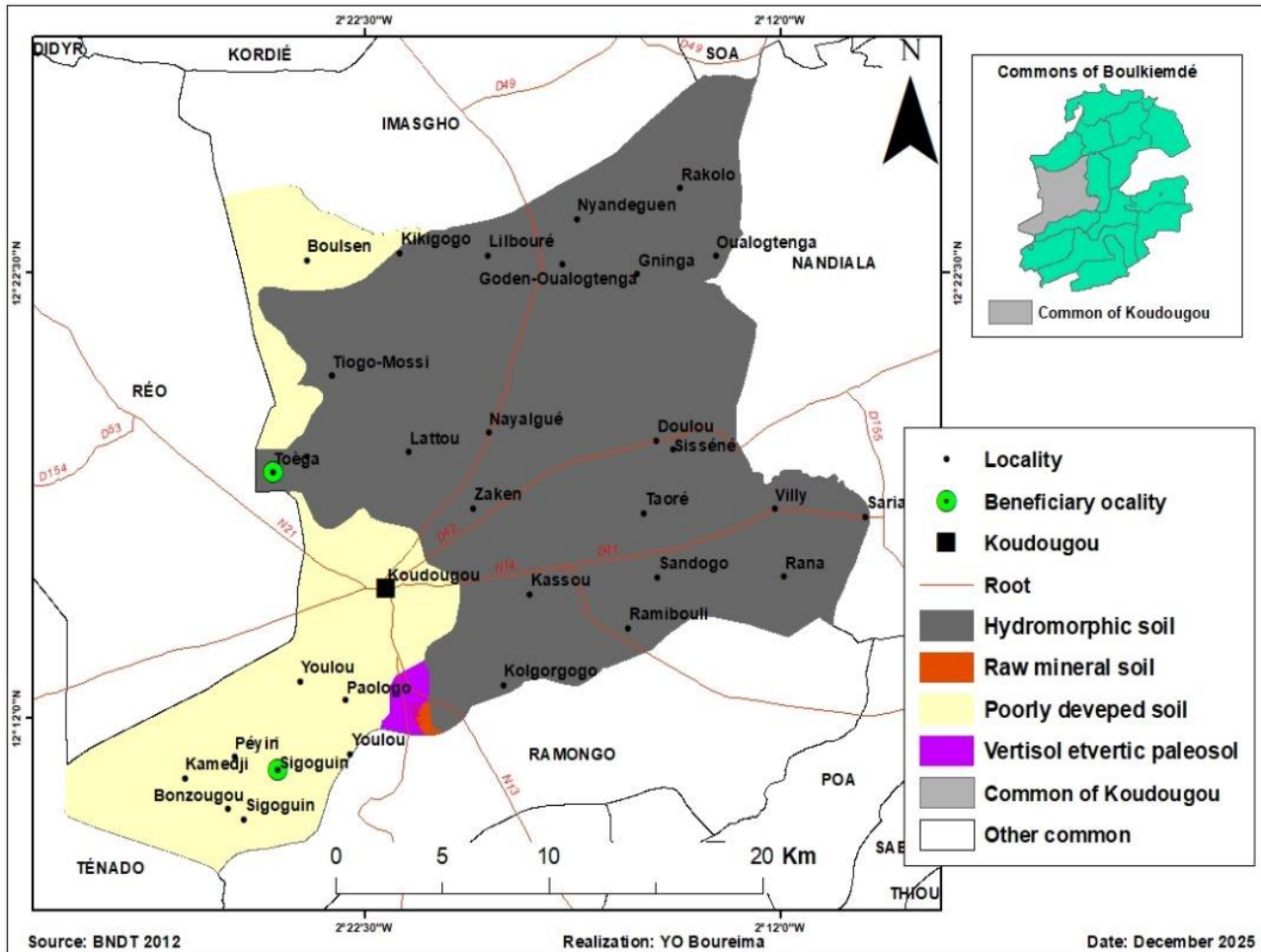


Figure 1. Distribution of boreholes in villages.

The boreholes studied were drilled as part of the Emergency Territorial Development and Resilience Project (PUDTR). Two beneficiary villages, Toéga and Siguoguin, were selected as study sites because of their almost exclusive dependence on groundwater for drinking water supply and the availability of physico-chemical analysis results.

2. 2. Field setup and sample collection

Drilling work (see Photo 1) was carried out in July 2025, during the rainy season, a period characterized by groundwater recharge and intensified agricultural activity.



Photo 1. Drilling operation in Toéga (09/07/2025).

This timing allows water quality to be assessed in a sensitive hydrological context, which is likely to influence physical and chemical parameters. Water samples were taken directly from active boreholes, after first purging the pipes to remove any stagnant water. This step was designed to ensure that the samples were representative of the water actually consumed by the population.

The samples were collected in clean bottles, rinsed with water from the borehole, then stored under appropriate conditions (in a cooler, protected from light) before being transported to the analysis laboratory (Laboratoire H₂O, Ouagadougou, Burkina Faso). The sampling procedures complied with international recommendations for sampling water intended for human consumption (WHO, 2017).

2. 3. Physicochemical analyses of water

These analyses were carried out in an accredited laboratory, in accordance with standard water analysis methods. The parameters analyzed cover the main characteristics of groundwater potability and mineralization, such as:

- physical parameters: temperature, pH, electrical conductivity, and turbidity;
- major chemical parameters: total hardness, calcium, magnesium, chlorides, sulphates;
- pollution indicator parameters: nitrates, nitrites, ammonium;
- specific elements: total iron, fluorides (depending on data availability).

The pH and electrical conductivity were used to assess the acidity/alkalinity of the water and its level of mineralization, respectively. Nitrates were considered a key indicator of anthropogenic pressures, particularly agricultural and domestic, while iron and fluoride were analyzed because of their frequent presence in Sahelian groundwater and their potential health implications.

2. 4. Reference to WHO drinking water standards

Table 1. WHO recommended drinking water quality standards.

Parameter	Unit	WHO guideline value	Significance / Risks in case of exceedance
Temperature	°C	No strict guideline value	Affects taste and microbial growth
pH	—	6.5 – 8.5	Corrosion of pipes, unpleasant taste
Electrical conductivity	µS/cm	≤ 1 500 (indicative)	High mineralization, salinity
Turbidity	NTU	≤ 5	Protection of microorganisms, acceptability
Total hardness	mg/L CaCO ₃	≤ 500 (indicative)	Scale buildup, unpleasant taste
Calcium (Ca ²⁺)	mg/L	≤ 200	High hardness
Magnesium (Mg ²⁺)	mg/L	≤ 150	Laxative effects at high doses
Chlorides (Cl ⁻)	mg/L	≤ 250	Salty taste, corrosion
Sulphates (SO ₄ ²⁻)	mg/L	≤ 250	Laxative effects
Nitrates (NO ₃ ⁻)	mg/L	≤ 50	Methemoglobinemia in infants
Nitrites (NO ₂ ⁻)	mg/L	≤ 0,2	Acute toxicity
Ammonium (NH ₄ ⁺)	mg/L	≤ 0,5	Recent pollution indicator
Fer total (Fe)	mg/L	≤ 0,3	Discoloration, metallic taste
Fluorides (F ⁻)	mg/L	≤ 1.5	Dental and bone fluorosis

Source: World Health Organization (WHO, 2017).

The results were interpreted by comparing them with the drinking water quality standards recommended by the World Health Organization (WHO) (WHO, 2017). These standards are an international reference widely used in environmental and hydrogeographical studies in Africa. The potability thresholds used include, in particular.

The parameters measured were classified into two categories:

- i) compliant with WHO standards, indicating acceptable quality for human consumption, and
- ii) non-compliant or close to thresholds, indicating potential risks to health and sustainability of water use.

2. 5. Water Quality Index

The Water Quality Index (WQI) takes into account numerous weighted and measurable parameters to provide a figure reflecting water quality (Lachhab, 2019). The Water Quality Index (WQI) is a tool that is very frequently used to describe water quality (Chidiac et al., 2023). The Water Quality Index (WQI) was determined using the following parameters: pH, electrical conductivity, chloride, dissolved solids, hardness, sulphate, sodium, manganese, calcium, potassium, and magnesium (Chaurasia et al., 2018). The following formula is used to calculate the WQI (Adebanjo, 2021):

$$q_i = \frac{C_i}{S_i} \times 100 \quad (1)$$

with, q_i , C_i = measured concentration, and S_i = WHO standard. w_i = relative weight.

$$w_i = \frac{1}{S_i} \quad (2)$$

$$WQI = \frac{\sum w_i \cdot q_i}{\sum w_i} \quad (3)$$

where: WQI is a number between 0 and 100 that represents the quality of drinking water (Kumar et al., 2024).

Table 2. Water quality classification.

Class	WQI value	Water quality status
I	0 – 25	Excellent
II	26–50	Good
III	51–75	Poor
IV	76–100	very poor
V	>100	Unsuitable for drinking

Source: Brown et al. (1972).

2. 6. Water Quality and environmental

Water quality can indeed have an impact on agriculture and plant species development. Kumar et al. (2024) used several indices, including the sodium adsorption ratio (SAR), sodium percentage (Na %), and permeability index (PI), to assess water, soil, and plant quality, as well as their impact on agriculture. This study takes these indices into account in order to understand the influence of water quality on the environment of the two villages in the municipality of Koudougou.

2. 6. 1. Sodium adsorption ratio (SAR)

The Sodium Adsorption Rate (SAR) is a standard measure of the potential risk associated with the presence of sodium in irrigation water (Liu et al., 2022). This indicator is essential for assessing the quality of irrigation water. It makes it possible to evaluate the risk of soil sodification, i.e., the alteration of soil structure and physical properties due to sodium accumulation, as well as the risk of degradation of soil permeability, i.e., its ability to allow water and nutrients to pass through. This risk is mainly linked to a predominance of sodium over calcium and magnesium in the soil. According to U.S. Salinity Laboratory Staff, 1954, its mathematical formula is as follows:

$$\text{Sodium adsorption ratio (SAR)} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad (4)$$

where, $[Na^+]$, $[Ca^{2+}]$, $[Mg^{2+}]$ are expressed in meq/L (milliequivalents per liter).

A high SAR indicates a risk of soil sodification. Sodium then replaces calcium and magnesium in the clay-humic complex. This leads to:

- reduced permeability;
- clay dispersion.
- reduced permeability;
- decreased water infiltration;
- root asphyxia.

Table 3 below shows SAR and water quality levels.

Table 3. Classification of SAR.

Order	Ranges	Water quality
I	0–10	Excellent
II	10–18	Good
III	18–26	Doubtful
IV	>26	Unsuitable

Source: Richards, (1954); Kumar et al. (2024).

2. 6. 2. Percent sodium (%Na)

The sodium percentage (Na %) is a commonly used index for assessing the quality of irrigation water, particularly the risk of soil sodification and reduced permeability when applied repeatedly. According to Wilcox (1955), its formula is as follows:

$$\text{Percent sodium } (\%Na) = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100 \quad (5)$$

Table 4. Classification of percent sodium.

Order	Ranges	Water quality
I	<20	Excellent
II	20–40	Good
III	40–60	Permissible
IV	60–80	Doubtful
V	>80	Unsuitable

Source: Wilcox, (1955).

The hydraulic and agronomic consequences are:

- Decreased hydraulic conductivity
- Surface water stagnation
- Poor soil aeration
- Root asphyxia
- Decreased crop growth and yield. It is therefore important to use this index.

2. 6. 3. Permeability index (PI)

Table 5. Classification of PI.

Order	Ranges	Water quality
I	>75	Excellent
II	25–75	Good
III	<25	unsuitable

Source: Doneen, (1964); Kumar et al. (2024).

Soil permeability plays an essential role in the environment. Soil with good permeability allows water to infiltrate evenly, ensuring sufficient water reserves and well-hydrated roots.

However, the level of permeability is influenced by the ionic composition of the soil solution, particularly by $[Na^+]$, $[Ca^{2+}]$, $[Mg^{2+}]$, and $[HCO_3^-]$ ions, which modify the structure of fine particles (Quirk and Schofield, 1955). Doneen (1964) presents his mathematical formula as follows:

$$Permeability\ index\ (PI) = \frac{Na^+ + \sqrt{Hco_3^-}}{(Ca^{2+} + Mg^{2+} + Na^+)} \quad (6)$$

3. RESULTS

3. 1. Analysis of physicochemical parameters

The results of the physicochemical analyses of borehole water in the villages of Toega and Siguoguin are presented and interpreted by comparison with the World Health Organization (WHO) drinking water standards.

Table 6. Comparison of physicochemical parameters of borehole water and WHO standards.

Parameter	Unit	WHO standard	Toega	Siguoguin	Environmental assessment
pH	--	6.5 - 8.5	6.72	7.14	Weakly acidic to neutral waters. chemically stable
Temperature	°C	--	26.8	29.2	Seasonal influence (rainy season)
Turbidity	NTU	≤ 5	3.12	4.7	Good clarity. slight influence of runoff
Conductivity	μS/cm	≤ 1 500	235	334	Low mineralisation. bedrock aquifer
TDS	mg/L	≤ 1 000	118	158	Fresh water. good acceptability
TAC	°f	--	3	5	Low buffering capacity
Carbonates	mg/L	--	0	0	Absence of carbonates. low mineralisation
Bicarbonates	mg/L	--	36.6	61	Moderate water–rock interaction
Total hardness	mmol/L	≤ 5	0.7	1.2	Soft to slightly hard water
Calcium	mg/L	≤ 200	16	24	Moderate contribution to hardness
Magnesium	mg/L	≤ 150	7.26	14.52	Without health risks
Chlorides	mg/L	≤ 250	35.5	35.5	Absence of salinisation
Sulphates	mg/L	≤ 250	< 1	< 1	Absence of industrial pollution
Ammonium (NH ₄ ⁺)	mg/L	≤ 0.5	< 0.01	< 0.01	No recent organic pollution

Nitrates (NO ₂ ⁻)	mg/L	≤ 0.2	0.023	0.015	Very low nitrogen contamination
Nitrites (NO ₃ ⁻)	mg/L	≤ 50	2.1	6.3	Low agricultural pressure
Total iron	mg/L	≤ 0.3	0.05	< 0.01	No aesthetic issues
Orthophosphates	mg/L	--	0.62	0.55	Traces linked to agricultural practices
Total phosphorus	mg/L	--	0.2	0.14	Low anthropogenic influence
Sodium	mg/L	≤ 200	2.5	1.6	Very low salinity
Potassium	mg/L	--	0.8	0.3	Low ionic contribution

Source: Field analyses (July 2025) and WHO (2017)

The pH of the water analyzed is 6.72 in Toega and 7.14 in Siguoguin. These values are within the range recommended by the WHO (6.5-8.5), indicating low acidity to neutrality, which is characteristic of groundwater in the Sahel region. A pH close to neutrality promotes good water acceptability and limits corrosion or precipitation phenomena (WHO, 2017).

The water temperature is 26.8 °C in Toega and 29.2 °C in Siguoguin, values consistent with the ambient temperature and the shallow depth of the aquifers. Although no WHO guideline value has been set for this parameter, relatively high temperatures can affect the taste of the water and promote microbial growth, without posing a direct risk in this case.

Turbidity is 3.12 NTU in Toega and 4.7 NTU in Siguoguin, which is below the 5 NTU threshold recommended by the WHO. These results indicate good water clarity, reflecting a low presence of suspended solids. However, the relatively higher value observed in Siguoguin could be linked to increased mobilization of fine particles during the rainy season.

Electrical conductivity is 235 µS/cm in Toega and 334 µS/cm in Siguoguin, indicating low mineralization of the water. The associated TDS values (118 mg/L and 158 mg/L) confirm this low ionic load. These results are well below WHO guideline thresholds and indicate soft water, generally well accepted for human consumption. The slightly higher conductivity at Siguoguin suggests more pronounced water-rock interaction or a longer residence time of water in the aquifer.

Total alkalinity (TAC) is 3 °f at Toega and 5 °f at Siguoguin, while carbonates are absent from both boreholes. Bicarbonates are present in moderate concentrations (36.6 mg/L at Toega and 61 mg/L at Siguoguin), reflecting the low buffering capacity of the water. These results confirm the low mineralization of the water and its relative chemical stability, characteristics of shallow bedrock aquifers.

Total hardness is 0.7 mmol/L at Toega and 1.2 mmol/L at Siguoguin, indicating that the water is soft to slightly hard. Calcium (16 mg/L and 24 mg/L) and magnesium (7.26 mg/L and 14.52 mg/L) concentrations remain well below WHO guideline values. These hardness levels are favorable for domestic use, limiting scaling problems and contributing to good taste acceptability.

Chloride concentrations are identical in both villages (35.5 mg/L), which is well below the WHO threshold of 250 mg/L. Sulphate levels are below 1 mg/L in both boreholes, indicating

the absence of industrial or evaporative pollution. These results confirm the absence of salinization and significant chemical contamination in the groundwater studied.

Ammonium concentrations are below 0.01 mg/L in both boreholes, indicating no recent organic pollution. Nitrite levels are very low (0.023 mg/L in Toega and 0.015 mg/L in Siguoguin) and remain well below the WHO threshold (0.2 mg/L).

Nitrate levels are 2.1 mg/L in Toega and 6.3 mg/L in Siguoguin, well below the WHO limit of 50 mg/L. These low concentrations reflect limited anthropogenic pressure, despite the agricultural context and the sampling period during the rainy season.

Total iron is 0.05 mg/L in Toega and less than 0.01 mg/L in Siguoguin, values well below the WHO standard (0.3 mg/L). The absence of excessive iron reduces the risk of discoloration, metallic taste, and deposits in water infrastructure.

Orthophosphates are present at concentrations of 0.62 mg/L in Toega and 0.55 mg/L in Siguoguin, while total phosphorus remains low. Although the WHO does not set strict health thresholds for these parameters, their presence in low concentrations may be linked to agricultural activities and does not pose a risk to potability.

The concentrations of sodium (2.5 mg/L and 1.6 mg/L) and potassium (0.8 mg/L and 0.3 mg/L) are very low, confirming the good chemical quality of this water intended for human consumption.

Overall, the borehole water in the villages of Toega and Siguoguin is of good physical and chemical quality, with all parameters analyzed complying with WHO drinking water standards. The slight variability observed between the two sites reflects local hydrogeological conditions and interactions between water and the environment, without revealing any major health risks.

3. 2. Water quality and local environmental context

3. 2. 1. Water quality in the two villages

The quality of the water from the two boreholes is very good. The SQI is 12.04 in Toega and 6.04 in Siguoguin (see Tables 7 and 8).

Table 7. Excellent quality of borehole water in Toega.

Parameter	Ci	Si	Wi = 1/Si	Qi	SI = Wi×Qi
pH	6.72	8.5	0.11765	79.05882	9.30104
TDS	118	1 000	0.00100	11.80000	0.01180
Calcium	16	75	0.01333	21.33333	0.28444
Magnesium	7.26	50	0.02000	14.52000	0.29040
Chlorides	35.5	250	0.00400	14.20000	0.05680
Sulphates	1	250	0.00400	0.40000	0.00160
Ammonium (NH ₄ ⁺)	0.01	0.5	2.00000	2.00000	4.00000

Nitrates (NO_2^-)	0.023	0.2	5.00000	11.50000	57.50000
Nitrites (NO_3^-)	2.1	50	0.02000	4.20000	0.08400
Total iron	0.05	0.3	3.33333	16.66667	55.55556
Sodium	2.5	200	0.00500	1.25000	0.00625
Potassium	0.8	12	0.08333	6.66667	0.55556
Sum			10.60165		127.64744
WQI				12.04	

Table 8. Excellent quality of borehole water in Siguoguin.

Parameter	Ci	Si	Wi = 1/Si	Qi	SI = Wi×Qi
pH	7.14	8.5	0.11765	84.00000	9.88235
TDS	158	1 000	0.00100	15.80000	0.01580
Calcium	24	75	0.01333	32.00000	0.42667
Magnesium	14.52	50	0.02000	29.04000	0.58080
Chlorides	35.5	250	0.00400	14.20000	0.05680
Sulphates	1	250	0.00400	0.40000	0.00160
Ammonium (NH_4^+)	0.01	0.5	2.00000	2.00000	4.00000
Nitrates (NO_2^-)	0.015	0.2	5.00000	7.50000	37.50000
Nitrites (NO_3^-)	6.3	50	0.02000	12.60000	0.25200
Total iron	0.01	0.3	3.33333	3.33333	11.11111
Sodium	1.6	200	0.00500	0.80000	0.00400
Potassium	0.3	12	0.08333	2.50000	0.20833
Sum			10.60165		64.03946
WQI				6.04	

These two tables reveal low mineralization of the water observed in the Toega and Siguoguin boreholes (conductivity < 350 $\mu\text{S}/\text{cm}$; TDS < 160 mg/L). This reflects moderate interaction between groundwater and the geological substrate.

This characteristic is typical of aquifers in the crystalline bedrock, which are widespread in the central-western region of Burkina Faso (Nando), where the aquifers are shallow and the residence time is short (Jourda et al., 2007; Taylor et al., 2013). The low bicarbonate content and absence of carbonates indicate low water buffering capacity, making the aquifers sensitive to environmental variations and anthropogenic pressures. Thus, although the current quality is satisfactory, these waters remain vulnerable to future degradation in the event of changes in land use or agricultural intensification around the boreholes.

As the samples were taken in July 2025, in the middle of the rainy season, the results reflect a hydrological context marked by active groundwater recharge. In many rural areas of the Sahel, this period is generally associated with an increased risk of diffuse contamination through leaching from agricultural soils and infiltration of runoff water (Lapworth et al., 2017).

The low concentrations of nitrates, nitrites, and ammonium observed in both villages suggest that the boreholes currently benefit from a relatively unspoiled immediate environment, with agricultural and domestic pressure still limited in the vicinity of water sources. This favorable situation can be interpreted as the combined result of:

- moderate population density;
- low-intensity land use around the boreholes;
- and relatively adequate siting of the structures in relation to potential sources of pollution.

3. 2. 2. Water quality, soil and agriculture

The water supplied by the borehole is suitable for human consumption. Its effects on agriculture in the two villages show different results. In the village of Toega, various indicators such as SAR and %NA are excellent (Table 9), meaning that there is no risk of soil sodification in the village. The water can therefore be used for irrigation in the village.

Table 9. Water from the borehole suitable for irrigation in the village.

Index	Toega	Water quality
SAR	0.73	Excellent
%NA	12	Excellent
PI	0.33	Good

In the village of Siguoguin, the risk of soil sodification is also ruled out, as the SAR and %NA values are very low (see Table 10). However, the permeability level is very low. This situation has consequences for the soil and vegetation. At ground level, there could be surface water stagnation, which could promote water erosion around the borehole.

It should also be noted that the soil is poorly aerated and plant roots are suffocated. In terms of vegetation, there could be limited root development, a risk of disease (root rot), a preference for moisture-tolerant plants, and slow growth or death of plants that are less sensitive to moisture.

Table 10. Water from boreholes less suitable for irrigation in the village of Siguoguin.

Index	Siguoguin	Water quality
SAR	0,36	Excellent
%NA	5	Excellent
PI	0,23	unsuitable

4. DISCUSSION

The results of the physical and chemical analyses of the borehole water in Toega and Siguoguin reveal satisfactory overall quality, with all parameters complying with the World Health Organisation (WHO) standards for drinking water.

These results confirm the central role of groundwater as a strategic resource for drinking water supply in rural Sahelian areas, as highlighted by Foster and Chilton (2003) and Howard et al. (2006).

4. 1. Chemical quality of water and hydrogeological context

The low mineralisation observed, characterised by electrical conductivity values below 350 $\mu\text{S}/\text{cm}$ and TDS values below 160 mg/L, is consistent with the hydrogeological characteristics of the crystalline basement aquifers widely found in Burkina Faso.

Similar results have been reported by Jourda et al. (2007) and Edmunds and Smedley (2013), who point out that these aquifers generally produce low-mineralised fresh water due to the relatively short residence time of the water in the rock environment.

The dominance of low concentrations of bicarbonates, combined with the absence of carbonates, confirms moderate water-rock interaction and low buffering capacity. According to Taylor et al. (2013), this type of configuration makes bedrock aquifers particularly sensitive to anthropogenic pressures and changes in land use, highlighting the need for preventive management of recharge areas.

4. 2. Anthropogenic pressures and diffuse pollution

The very low concentrations of nitrates, nitrites and ammonium observed in the two boreholes indicate the absence of significant nitrogen contamination, despite the agricultural context and the sampling period during the rainy season.

This situation contrasts with the results of Lapworth et al. (2017) and Gaye and Tindimugaya (2019), who found high levels of nitrates in several rural African aquifers subject to intensive agriculture and uncontrolled urbanisation.

This difference can be explained by the still moderate agricultural pressure around the boreholes studied and by the relatively adequate location of the structures in relation to potential sources of pollution (latrines, crop areas). It highlights the importance of spatial planning for water infrastructure, an aspect that is often neglected in rural development projects.

4. 3. Iron, major elements and water acceptability

Total iron concentrations below 0.3 mg/L indicate no aesthetic or technical constraints related to the presence of iron, contrary to what has been observed in certain bedrock areas in West Africa (Edmunds & Smedley. 2013). This favourable situation improves the social acceptability of the water and reduces the risk of damage to water infrastructure. The low levels of chlorides, sulphates, sodium and potassium confirm the absence of salinisation and industrial pollution, which is consistent with the essentially rural and agricultural nature of the areas studied. According to the WHO (2017), these parameters are key indicators of the sustainability of groundwater use in rural areas.

5. CONCLUSIONS

This study aimed to assess the physical and chemical quality of borehole water produced as part of the Emergency Territorial Development and Resilience Project (PUDTR) in the municipality of Koudougou. The results of the analyses show that the borehole water in the villages of Toega and Siguoguin is of good physical and chemical quality, with all parameters analysed complying with the drinking water standards recommended by the World Health Organisation (WHO). The low levels of mineralization, nitrates, iron and other potentially problematic elements indicate that the groundwater resource is generally well preserved, despite the rainy season and the presence of agricultural activities. These results confirm the strategic role of bedrock aquifers as the main source of drinking water in rural Sahelian areas, while highlighting their potential vulnerability to changes in land use and intensification of use. Beyond compliance with standards, the study highlights the fact that current water quality constitutes a baseline in a changing region, marked by the implementation of structural infrastructure such as rural roads and boreholes. Integrating water quality into regional analysis thus appears to be an essential lever for ensuring the environmental and health sustainability of public investment in rural areas.

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