# Assessment of the Quality and Potability of GroundwaterfromBoreholes in the Peripheral Areas of Niamey.

## Abstract

The city of Niamey has experienced rapid population growth and urban expansion in recent years, leading to difficulties in accessing safe drinking water in several urban and peri-urban areas. In response to this situation, part of the population relies on water from boreholes, whose quality remains uncertain. The present study aims to evaluate the physico-chemical potability of water from selected boreholes located in the peripheral districts of Niamey. Eight samples were collected and analyzed using standardized methods, including volumetric and spectrometric techniques, at the laboratory of the Niger Water Exploitation Company (SEEN). The results show that more than 80% of the boreholes have physico-chemical quality that complies with the drinking water standards established by the World Health Organization (WHO). However, two boreholes exhibit exceedances of certain recommended chemical values, which may pose a health risk to consumers.

**Keywords:** Water, Borehole, Potability, Niamey, Peri-urban.

# 1. Introduction

The issue of water has become particularly pressing today, both at the global level and in countries characterized by limited water resources. Despite the efforts of the international community to improve this situation, the problem remains alarming. Of the 783 million people who lack access to safe drinking water, more than half live in Africa (Dione, 2014). The growing gap between supply and demand, competition among different uses (agriculture, industry, tourism), pollution of water resources, and the prevalence of waterborne diseases represent major challenges for both developing and industrialized countries (Nanfack et al., 2014; Faye, 2017; Monjour et al., 2005).

In Africa, access to safedrinking water remainsparticularlyproblematic. The continent is the region of the world whereurban areas are the mostdisadvantaged, withonlyhalf of the urban population havingaccess to quality water (Dos Santos, 2012; AFC, 2016). Rapid population growth, combinedwithacceleratedurbanization and difficultsocio-economic conditions, isplacingincreasing pressure on availableresources. In thiscontext, some populations resort to alternative solutions for their water supply.

Given the vital importance of water, it is essential to ensure safe access to good-quality water, not only for domestic consumption and hygiene (Mohamed, 2025; WHO, 2018; Houeha, 2007), but also for essential productive activities such as agriculture. According to WHO guidelines (2020), water safety and quality are fundamental pillars of human development and well-being. Access to reliable drinking water is indeed one of the most effective means of promoting public health and reducing poverty. In this perspective, regulations related to drinking water safety constitute a central tool for health protection, both in industrialized and developing countries (Jimba & Long Sieber, 2023; Sy et al., 2014; Kamgho, 2010).

Niamey, the capital of Niger, has experienced strong demographic growth for several decades (Chippaux et al., 2002; Dongo et al., 2008), accompanied by rapid urban expansion. This dynamicexertsconsiderable pressure on drinking water supply infrastructure, particularly in peripheralneighborhoodswhere public networks remaininsufficient.

Facedwiththeseconstraints, a significant portion of the population relies on groundwaterresourcesthroughttraditionalwells and boreholes. However, some of thesefacilitiespresent contamination risksrelated to their location, the lack of adequatesanitary protection, and theirproximity to potential sources of pollution.

Furthermore, in recentyearsthere has been a multiplication of domesticboreholes (privateboreholes) as well as semi-industrialboreholesintended for the commercialization of packagedwater. However, most of thesefacilities are constructed and operatedwithoutsystematic and rigorous monitoring of the physicochemical and bacteriologicalquality of the water.

In thiscontext, the central issue lies in assessing the quality of the groundwaterexploited in Niamey and evaluating the healthrisksassociatedwithitsconsumption. The absence of regular monitoring and compliance control thereforeraises major public health and sustainable water resource management concerns.

## 2. Materials and Methods

### 2.1 Description of the Study Area

The city of Niamey islocated in southwestern Niger, between latitudes 13°28′ and 13°35′ North and longitudes 02°03′ and 02°12′ East (Figure II-1). It covers an area of approximately 239 km² (Motcho, 2006). The Niger River flowsthrough the city in a northwest–southeast direction.

The relief isgenerallygentle. On the leftbank of the river, upstream of the alluvial plain, thereis a plateau rising to approximately 230 m abovesealevel. Urbandevelopment in Niamey mainlytakes place on this plateau, whichiscovered by relativelythin CT3 formations.

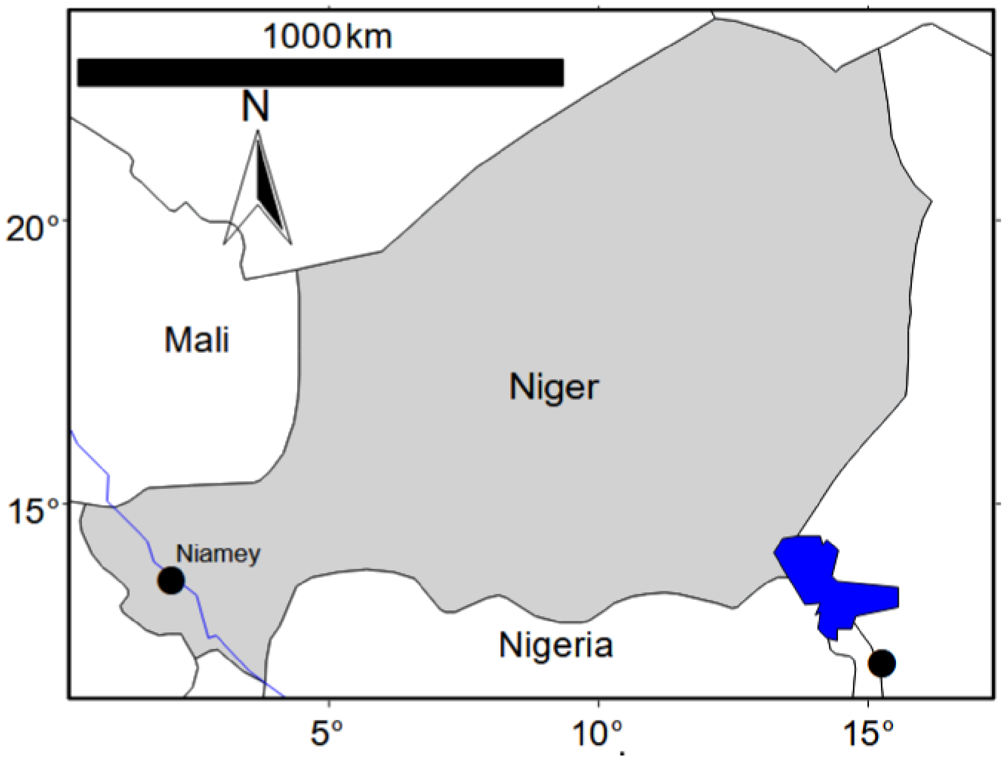

Figure 1: Study Area

### 2.2 Sampling

Water sampling constitutes a crucial step, as the reliability of analytical results and their interpretation directly depend on it (Rodier et al., 2009). The adoptedprocedure first consisted of allowing the water to run for approximatelytwo (2) minutes in order to flush the system and obtain a representativesample. The flow rate wasthenreduced to ensurecontrolledsampling. The bottleswerefilled to the brim, avoidingany air bubbles, and thentightlysealed. The collectedsampleswereimmediatelyplaced in a cooler to preventanyalteration.

A total of eight (8) water points wereselected for sampling, as illustrated in Figure 2.

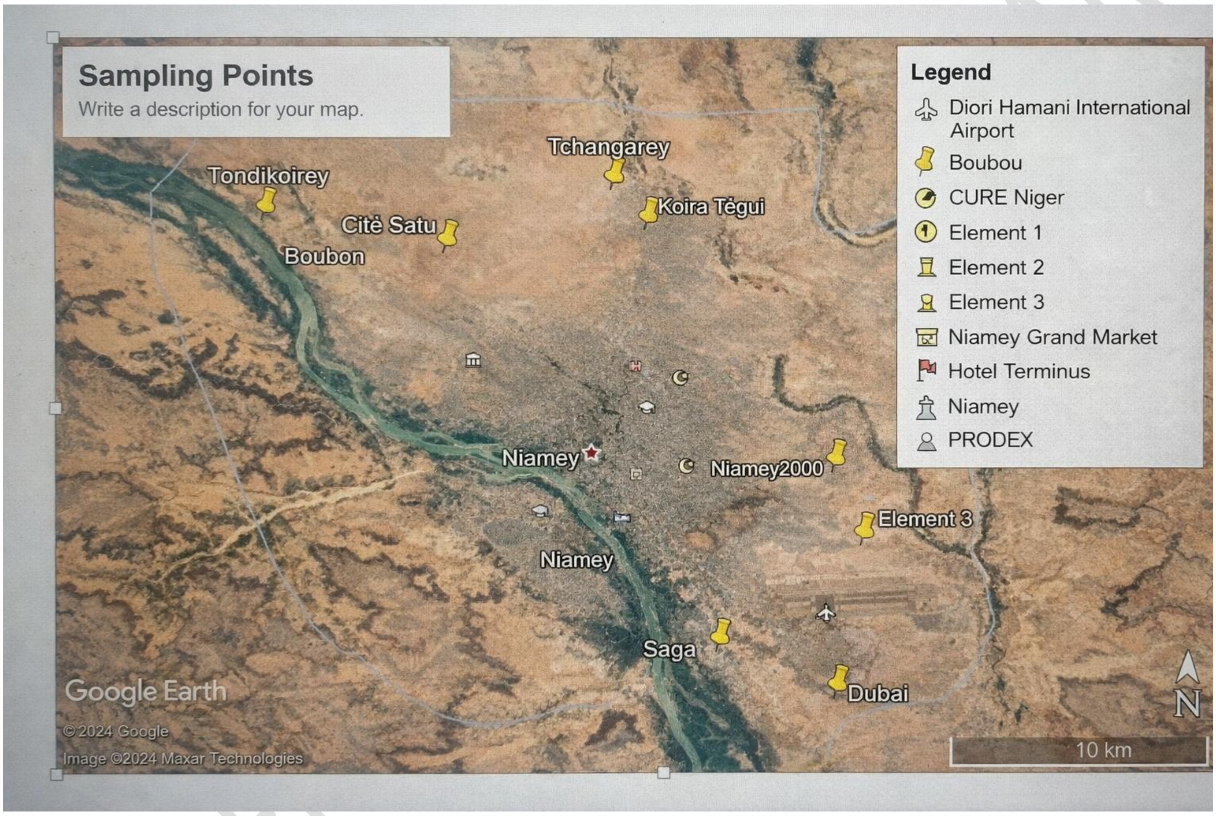

Figure 2: Sampling Points

### 2.3 Analysis of Physical and ChemicalParameters

Physicalparametersweremeasureddirectlyat the sampling sites, whilechemical analyses werecarried out in the laboratory.

Concentrations of nitrates ($NO_3^-$), nitrites ($NO_2^-$), fluorides ($F^-$), total iron, and residualchlorineweredetermined by spectrophotometryusing a Hach spectrophotometer. Total hardnesswasevaluated by complexometric titration using EDTA.

## 3. Results and Discussion

### 3.1 pH

The hydrogenpotential (pH) values of the analyzed water samples (Figure 3) range from 5.45 to 7.46. Approximatelyhalf of the boreholes show values below the lowerlimit of the WHO standard (6.5–9.5), indicating relative acidity of the water. This aciditymayberelated to severalfactors, includinganthropogenic inputs such as the use of fertilizers and pesticides in agriculture, or the infiltration of organic and industrialwastethatgeneratesacidic compounds. Natural processes, such as the dissolution of carbondioxide in groundwater or the weathering of silicate rocks, mayalsolower the pH.

From a practical perspective, a pH below 6.5 canmake water aggressive, promoting the corrosion of metal pipes and the release of metalsinto the distribution network.

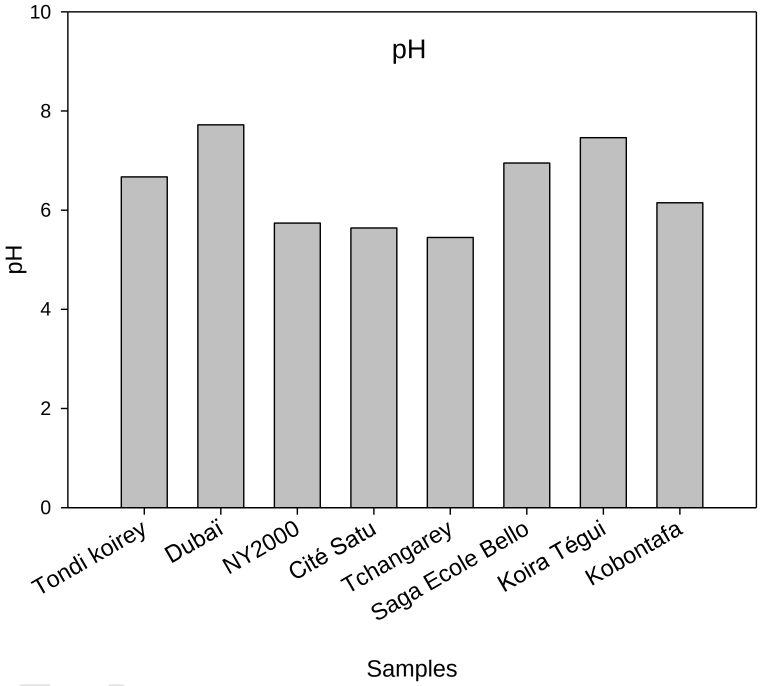

Figure 3: HydrogenPotential (pH) Diagram

### 3.2 Total DissolvedSolids (TDS)

Figure 4 presents the values of total dissolvedsolids (TDS) measured in the differentsamples. These values range from 18 mg/L to 1103.5 mg/L. The majority of the water points fallbelow the guideline value recommended by the WHO for drinking water (1000 mg/L). However, the Saga Éole borehole shows a particularly high content (1103.5 mg/L), slightlyexceeding the standard.

This high TDS concentration indicates excessive mineralizationresultingfrom a significantpresence of dissolvedsalts. Such a value can not only affect the organolepticquality of the water (salty or bitter taste) but mayalso have adverse effects on humanhealth, includingdigestive disorders (laxative effect) in sensitive individuals, as reported by Maoudo et al. (2020).

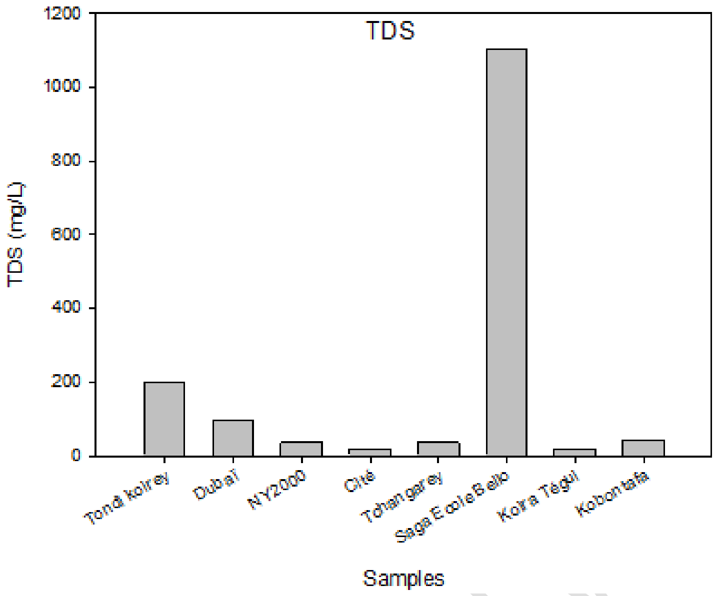

Figure 4 : Figure 4: TDS Diagram of the Analyzed Water Samples

### 3.3 Conductivity

The electricalconductivity values of the different water points are presented in Figure 5. Overall, the majority of the analyzedsamples have values within the range recommended by the WHO for drinking water (50 ≤ EC ≤ 400 µS/cm). However, the Ny2000 and KoiraTéguiboreholes show values below the minimum standard (50 µS/cm), indicating water withlowmineralization and thereforepoor in dissolvedsalts.

In contrast, the Saga Éole boreholeexhibits a very high value (2207 µS/cm), far exceeding the WHO guideline. This water isthereforehighlymineralized and shouldbeconsumed in moderation.

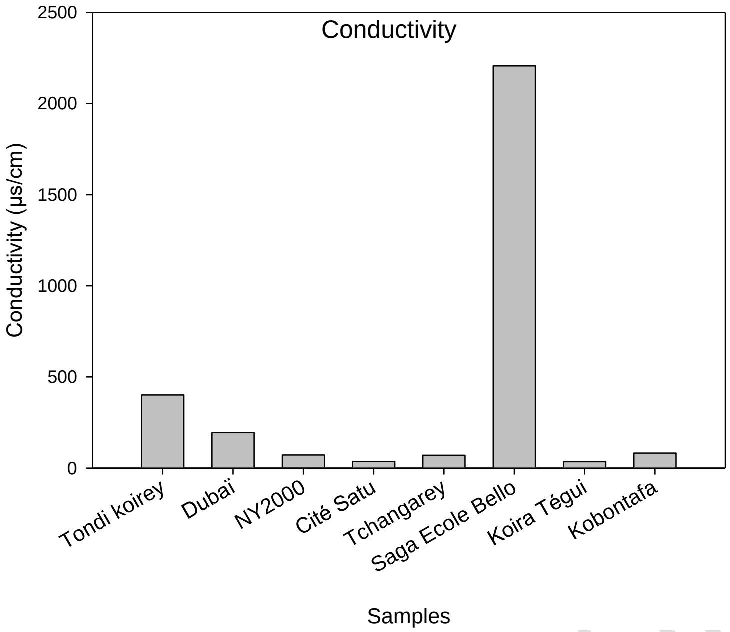

Figure 5 :Conductivity Diagram of the Analyzed Water Samples

### 3.4 Turbidity

The turbidity values of the analyzed water samples range from 0.5 to 25.6 NTU (Figure 6). The lowest value wasrecordedat the SAGA borehole (0.5 NTU), while the highest value wasobservedat the Cité Satu site (25.6 NTU). This high turbiditycanbeattributed to the presence of suspendedmaterials (clays, silts, organicmatter) as well as colloidalparticles capable of absorbing, scattering, or reflecting light.

From a regulatory perspective, the WHO guideline value for drinking water is set at 5 NTU. Thus, most of the analyzedsamplesfallbelowthisthreshold and are thereforecompliant. However, the high turbidityrecordedat Cité Satu (25.6 NTU) far exceedsthis standard, whichcould not only affect the aestheticquality of the water (cloudiness, coloration) but alsopromote the growth of microorganisms by protectingpathogensfrom the disinfecting action of chlorine.

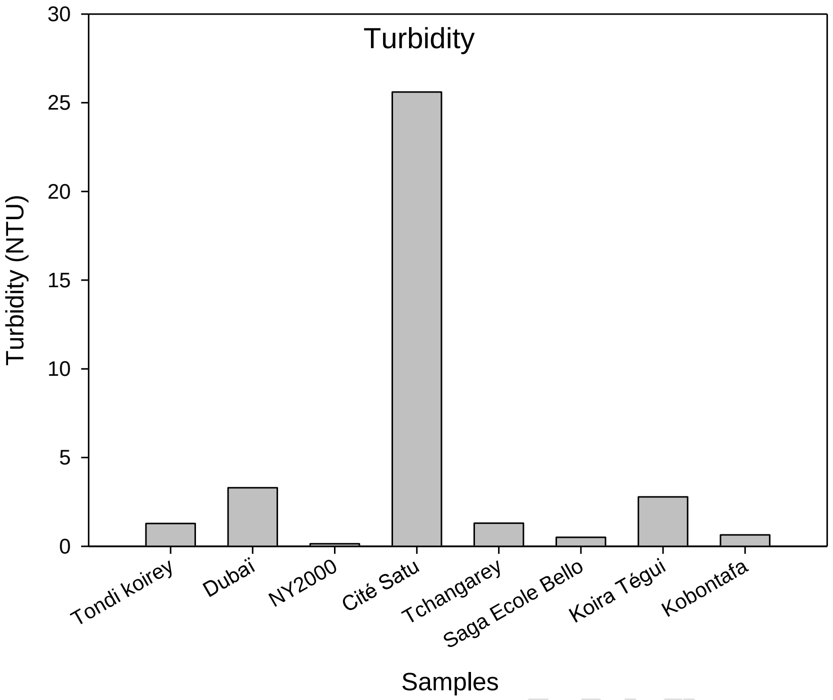

Figure 6 :Turbidity Diagram of the Analyzed Water Samples

### 3.5 Nitrates

The analysisresults show that nitrate concentrations in the different water points (Figure 7) range from 2.2 to 34.76 mg/L. All these values remainbelow the maximum limit of 50 mg/L set by the World HealthOrganization (WHO) for water intended for humanconsumption.

This situation reflects good water quality with respect to the nitrate parameter, suggesting a low influence of anthropogenic activities. However, the highest value recorded (34.76 mg/L) at the TondiKoireyborehole, althoughbelow the standard, couldindicate a local vulnerability of the borehole to diffuse pollution, probablylinked to agricultural practices or the proximity of humanactivitiesgeneratingdomesticwaste (Adjagodo, A. et al., 2016; SoltaniChamse Eddine, T.A., 2023; Youmbi et al., 2013).

From a health perspective, these concentrations do not pose an immediaterisk to the population, particularlyregarding infant methemoglobinemia, whichisoftenassociatedwith nitrate levelsexceeding the standard. However, regular monitoring isnecessary to preventany progression towardcriticallevels, especially in peri-urbanneighborhoodswhere pressure on water resourcesisincreasing.

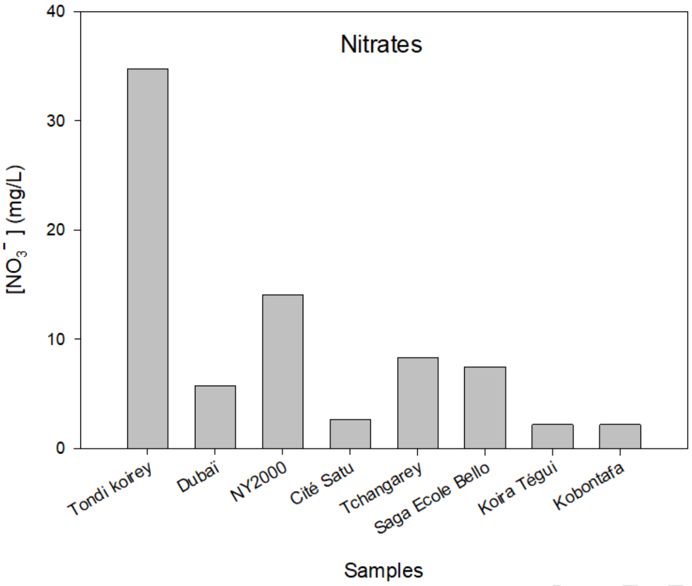

Figure 7 :NitrateDiagram of the Analyzed Water Samples

### 3.6 Nitrites

The concentrations of nitrite ions measured in the analyzed water (Figure 8) range from 0.013 to 0.03 mg/L. These values are well below the limit recommended by the World Health Organization (WHO) for water intended for human consumption, indicating good sanitary quality with respect to this parameter. This further supports the potability and health safety of the water concerning the metabolic risk associated with nitrites (methemoglobinemia, particularly in infants) (Faivre, J., et al., 1976; Chébékoué, S. F., 2008).

The low nitrite content canbeexplained by limiteddenitrificationactivity in the aquifer or by a notable absence of recentorganic pollution.

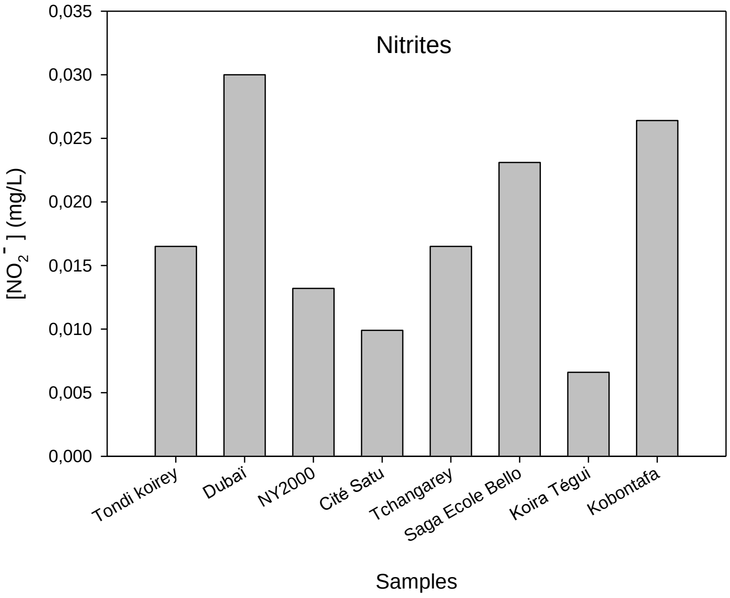

Figure 8 :Nitrite Diagram of the Analyzed Water Samples

### 3.7 Chloride Ions

Figure 9 illustrates the variation in chloride ion concentrations in the analyzedborehole waters. The values range from 10 to 225 mg/L, whichremainbelow the maximum limit of 250 mg/L set by the World HealthOrganization (WHO) for water intended for humanconsumption.

These results indicate that the groundwater in the study area complies with the potability standard regarding chlorides. From a health perspective, the measured concentrations do not pose a risk for consumption.

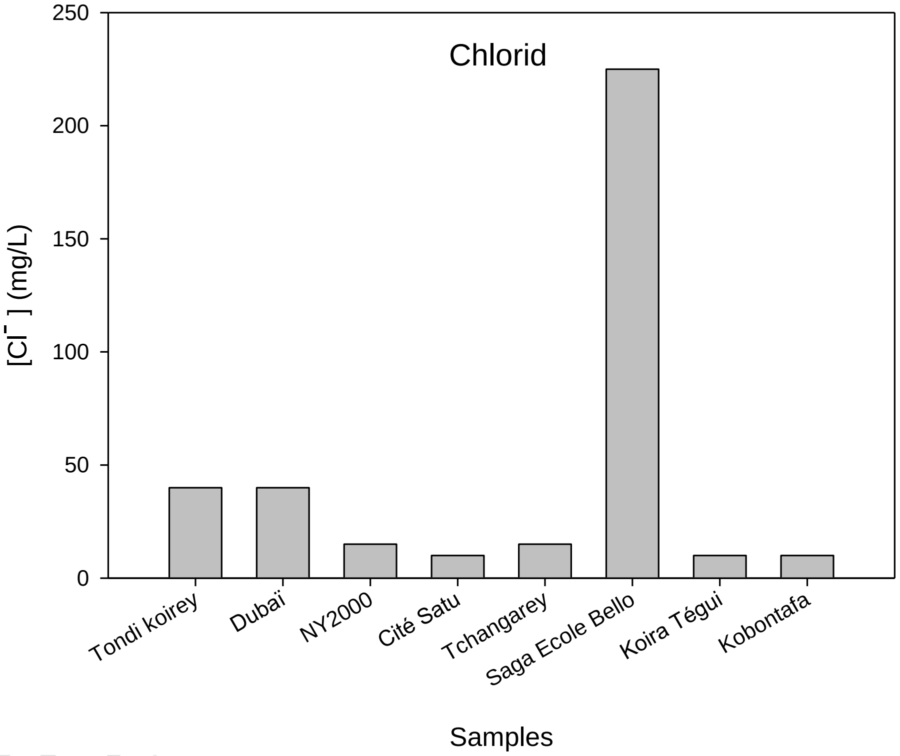

Figure 9 :Chloride Diagram of the Analyzed Water Samples

### 3.8 Fluoride Ions

Figure 10 presents the variation in fluoride ion concentrations in the analyzed water samples. Overall, the results show thatmost water points complywith the 1.5 mg/L limit set by the World HealthOrganization (WHO). However, a notable exception isobservedat the Dubaineighborhoodborehole, where the concentration reaches 2.46 mg/L, exceeding the guideline value.

This elevated concentration couldbeexplained by the geological nature of the aquifer, particularly the dissolution of fluoride-bearingminerals (fluorite, apatite) present in certain formations. Such a value, above the standard, exposes consumers to long-termhealthrisks, particularly dental fluorosis, and, withprolonged ingestion, skeletalfluorosis.

This situation highlights the need for enhanced monitoring of thisborehole, as well as the implementation of appropriate solutions (blendingwithlow-fluoride water, defluoridation techniques) to ensure the healthsafety of the local population.

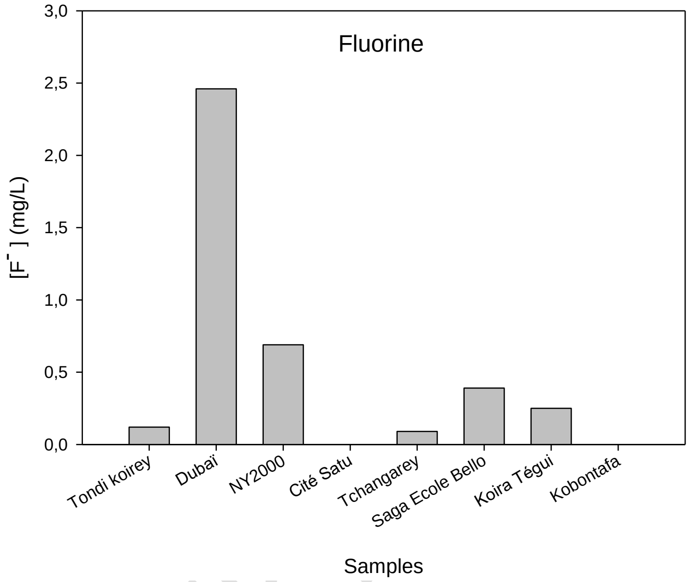

Figure 10 :FluorideDiagram of the Analyzed Water Samples

### 3.9 Sulfate Ions

The sulfate ion concentrations measured in the groundwater (Figure 11) range from 0 to 106 mg/L. These values are wellbelow the WHO guideline value of 500 mg/L. Thus, the analyzed waters do not pose a riskrelated to high sulfate mineralization.

This low content mayreflect a limited contribution of sulfate-bearinggeological formations (such as gypsiferous or evaporitic formations) to the chemical composition of the region’s waters. It alsoconfirmsthat the waters remainsuitable for humanconsumptionwith respect to thisparameter.

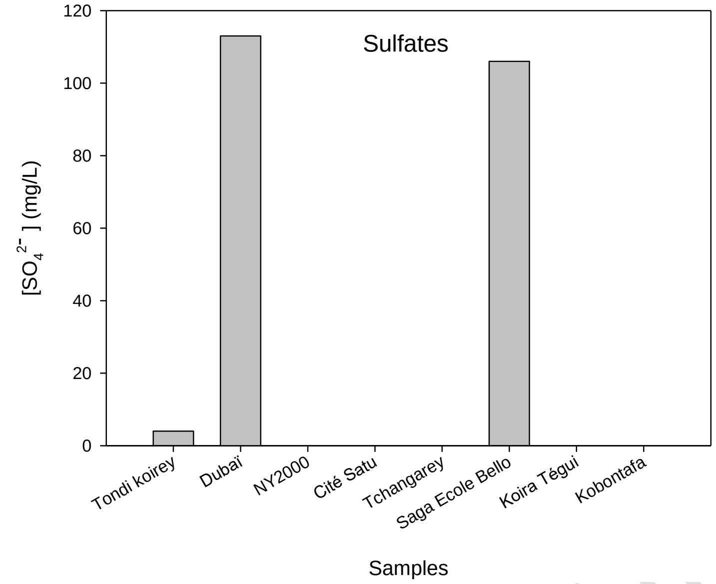

Figure 11 : Sulfate Diagram of the Analyzed Water Samples

### 3.10 Total Iron

The total iron concentrations in the analyzedgroundwater (Figure 12) range from 0 to 0.14 mg/L. All these values are below the WHO guideline limit of 0.3 mg/L. Therefore, the studied waters do not present a risk of discoloration, irondeposits, or organolepticalteration (metallic taste), which are oftenassociatedwith high iron content (FakhfekhHamdeni, R., 2017). Theseresultslikelyreflectlowmineralization of the aquifers in iron-bearingminerals and suggestthat the conditions for iron dissolution (pH, oxygenation, rock type) do not favorsignificantmobilization of thiselement in the study area.

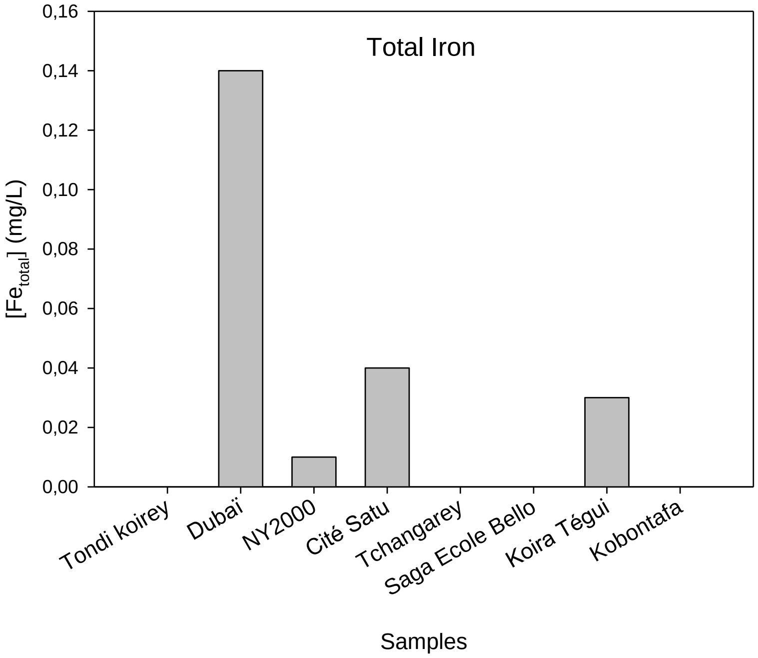

Figure 12 : Total IronDiagram of the Analyzed Water Samples

### 3.11 Total Hardness (TH)

The total hardness (TH) of the analyzedgroundwater ranges from 21 to 788 mg/L (Figure 13). The highest values, notablyrecordedat the Dubaineighborhoodborehole (788 mg/L) and the École Bello Saga borehole (678 mg/L), indicatestrong water mineralization, likelylinked to the dissolution of carbonate and/or gypsum rocks in the aquifer.

It shouldbenotedthatthereis no WHO guideline value for total hardness. However, from a practicalstandpoint, hardnessabove 500 mg/L isgenerallyconsidered excessive and can cause domesticinconveniences (scaling of pipes, deposits on householdequipment) as well as an unpleasant taste. Conversely, values below 150 mg/L correspond to so-called soft water, whichis more suitable for domestic use.

Thus, the waters from the Dubai and Bello Saga boreholes fall into the very hard water category, which could limit their acceptability for consumption and domestic use despite being safe from a health perspective.

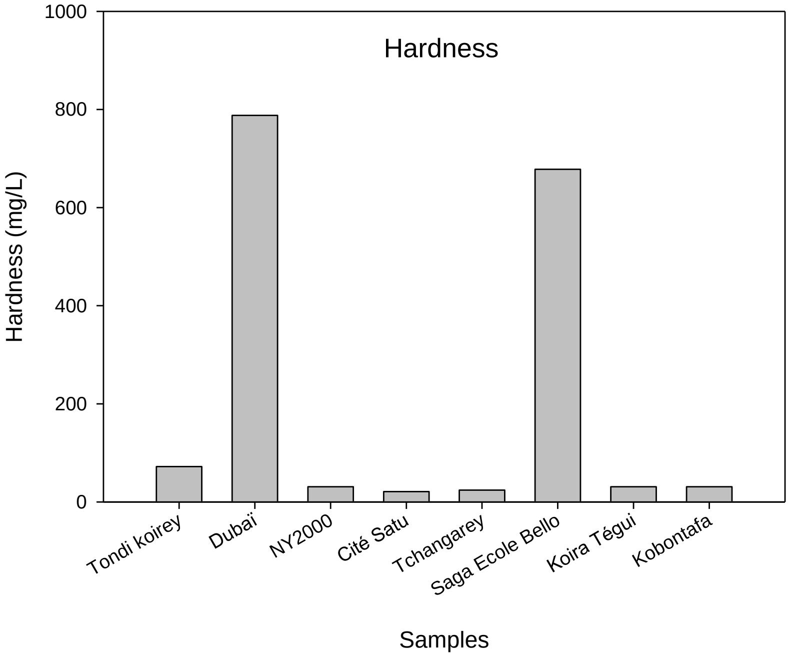

Figure 12 : Total HardnessDiagram of the Analyzed Water Samples

### 5. Conclusion

The studyshowedthat the majority of the physicochemicalparameters of the groundwatercomplywith the WHO potability standards. Overall, the boreholesexhibit a slightlyacidic to neutral pH, withmineralizationrangingfromlow to moderatedepending on the site. Only a few boreholes, notablythoseat Saga and Dubai, show certain parametersexceeding the standards.

In general, the waters remain soft and of acceptable physicochemical quality. The Koira Tégui and Tchangarey boreholes are characterized by very low mineralization, while the others fall within a moderate mineralization range. Overall, the waters are soft to moderately hard and present a generally acceptable physicochemicalquality.

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