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Evaluation of the physicochemical quality of groundwater Noumoubougou municipality of Tienfala in province of Koulikoro in Mali, 2022

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ABSTRACT: Introduction: Water resources in general and particularly drinking water are a constant concern for developing countries. The objective of this study is to evaluate the physico-chemical quality of various wells and boreholes in the locality of Noumoubougou (55m from the controlled dump) and in the vicinity of Tienfala in Mali. **Material and methods:** descriptive cross-sectional study from January to March 2022 on groundwater samples from the municipality of Tienfala. Samples from wells (42) and boreholes (48) were analyzed to determine the physico-chemical quality. **Results:** The results obtained highlight poor physico-chemical quality of some groundwater consumed by the population. Non-conformities measured in pH (5.43; 5.28); in nitrites (0.022mg/l; 0.023mg/l) and nitrates (50.57 mg/l; 53.33 mg/l; 113.91 mg/l) in water from domestic wells and boreholes (NO₃⁻, 51.28mg/l). On the other hand, concentrations in nickel (0.053 mg/l; 0.021 mg/l) and iron (0.301 mg/l; 0.434 mg/l) have exceeded the Malian standard for drinking water. This means that 37% of the groundwater sources in this village and surrounding areas have presented at least one non-compliant physico-chemical parameter. **Conclusion:** The results highlighted the poor physico-chemical quality of the water consumed by the populations at certain groundwater sources. This poor quality is generally due to high concentrations of nitrites, nitrates, ammonium, nickel, and iron found in domestic well water and boreholes.

KEYWORDS: Quality, physicochemical, groundwater, Noumoubougou.

I. INTRODUCTION

Water resources in general, and drinking water in particular, are a constant concern for developing countries. Water stress is likely to worsen further as climate change, increased water demand, waste, water scarcity, decreased rainfall, pollution, and population growth are all factors that generally threaten developing countries, particularly Mali [1]. The most important water reserves for human use are surface water and groundwater. Surface water consists of water that flows through the ground as streams, springs, and rivers, or that collects to form ponds, lakes, and seas. Unlike groundwater, surface water is located in underground aquifers and is connected to surface water by percolation, wells, and springs [2].

Access to clean drinking water has become a major issue for humanity. Hazardous substances such as pesticides, herbicides, and chemicals from farms, businesses, and landfills can be fatal or have a persistent toxic effect that can cause brain damage or cancer. These pollutants are responsible for a third of deaths from strokes, chronic respiratory diseases, and lung cancer. Asthma and other chronic respiratory illnesses are also linked to these diseases. Furthermore,

poorly controlled wastewater can contain bacteria and parasites that can contaminate drinking water sources and cause illnesses such as cholera, diarrhea, hepatitis A, typhoid fever, dysentery, and polio. These are just some of the diseases that can spread due to contaminated water and poor sanitation, heavy metals, inorganic waste, and radioactive materials [3]. To this end, the United Nations, through one of the Sustainable Development Goals (SDGs) adopted in 2015, committed to ensuring universal access to water and the sustainable management of water resources. Despite significant progress, more than 30% of the world's population still lacks access to safe drinking water services at home [4]. Having access to sufficient quantities of good quality water contributes to maintaining health. According to the World Water Forum, more than one billion people worldwide lack access to safe drinking water, and nearly 2.5 billion—one-third of the world's population—will face water scarcity by 2025. These resources are invaluable for a wide range of human activities [5]. In recent years, with terrorism in central Mali, particularly in Noumoubougou, people have been living near the Koulikoro region's landfill. However, the water used for human consumption draws directly from untreated groundwater. This consumption of raw water, combined with the presence of leachate from the landfill, can contribute to a source of waterborne diseases. The risk of groundwater pollution from landfill leachate is considered the most significant risk to the natural environment and human health associated with waste dumping. Furthermore, the most frequent health risk is bacterial contamination due to the presence of pathogenic microorganisms in groundwater [6]. This threat is detrimental to surface and groundwater sources and results from the toxicity of the leachate and its subsequent migration, which is a serious environmental pollution problem. Minimizing groundwater contamination beneath the landfill should be ensured by the leachate collection system and reinforced by proper landfill operation [7]. Poor water quality is thus responsible for 70 to 80% of diseases on the continent, with a heavy toll to pay for diarrheal diseases which constitute one of the main causes of infant mortality [8]. In India, 40 million Indians are affected each year by diseases caused by polluted water [9]. Diarrheal diseases affect approximately 2 billion people, including 1.7 billion children, worldwide each year. Niger is one of the most affected countries, with 484.6 deaths per 100,000 children under five in 2015. While progress has been made globally in reducing mortality from waterborne diseases [10]. In Mali, nitrate levels in all aquifers are locally high (P42), study area in Mali [11]. The degradation of solid and liquid waste can be a potential source of contamination through runoff and/or infiltration of surface or groundwater, leading to degradation of air, soil and water quality [12]. This lack of resources leads people in outlying neighborhoods to focus more on accessing water at a lower cost without considering the potential consequences [13]. Groundwater (wells and boreholes) was the common means of supplying drinking water in the event of a shortage in the drinking water network in most developing countries [14]. In particular, those in Noumoubougou, which are close to the landfill, could be exposed to all kinds of pollution (sewage, agricultural, industrial, and urban). However, there is little scientific data concerning the physicochemical quality of the groundwater in Noumoubougou and the surrounding Tienfala area. The existing data for Tienfala [15], [16] remain very limited, hence the choice of this study. The objective was to evaluate the physico-chemical quality of the groundwater of Noumoubougou by determining the chemical and bacteriological parameters.

II. MATERIALS AND METHODS

2.1. Study Setting: This study was conducted in the commune of Tienfala. The village of Tienfala is located approximately 30 km northeast of Bamako, the capital of Mali, on the RN27 highway in Koulikoro. It houses a solid waste landfill called the Noumoubougou landfill, located at 12°44'38.7312''N and 7°0.3204''W. The Noumoubougou landfill (photo 1) is located 55 meters from the village of Noumoubougou, 1.4 km from the village of Fougadougou, and 2.4 km from Manambougou [15]. The Commune covers an area of 3,001.25 km² (approximately 300,000 hectares).

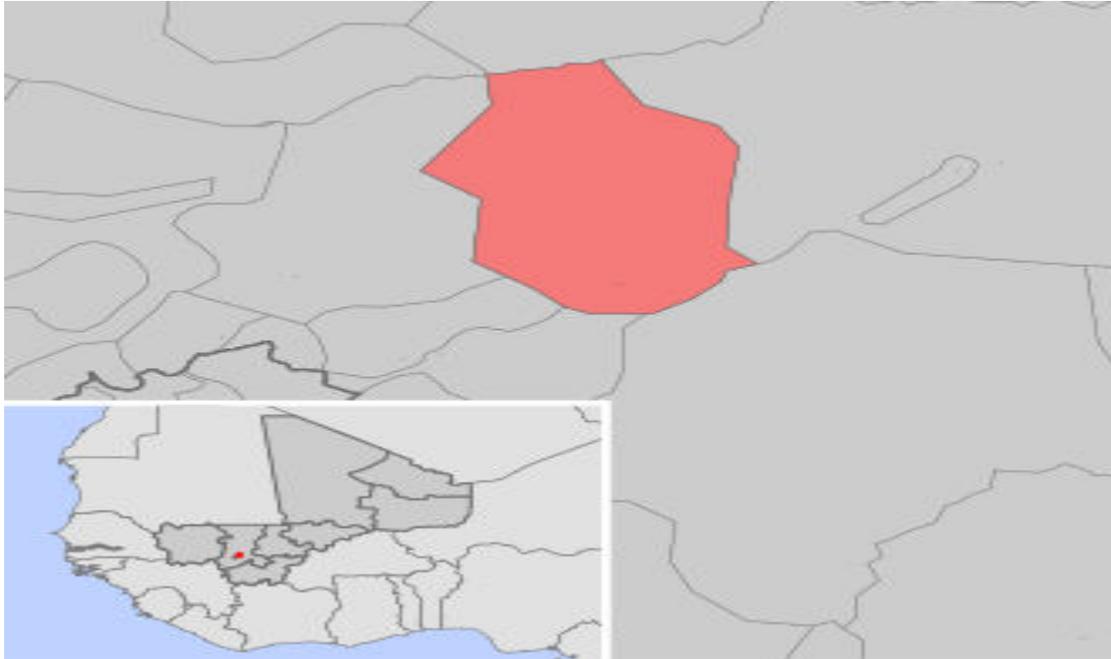


Figure 1 : source GoogleMap_ commune_Mali_-_TIENFALA.svg, 2022

On average, the static water level measured in all the domestic wells is 6.99 ± 1.41 m (groundwater). The depth of all these domestic wells varies from 3.68 to 11 m. They are generally individual or semi-collective, scattered on both sides of the RN27 highway.

2.2. Type and period of study: This was a descriptive cross-sectional study which took place from January to March 2022.

2.3. Study population: The study population consisted of water samples collected from the various groundwater sources already identified and georeferenced during our previous field trips.

2.4. Sampling: We conducted purposive sampling based on the georeferenced water sources.

Sampling: Water samples were collected from January to March 2022, with 30 samples taken per month using a 1.5-liter bottle. The codes for our samples are based on the first letter of the site name followed by the letters P (domestic well) or F (borehole) and the sample sequential numbers. However, all sampling points were limited to domestic wells and/or boreholes in the villages of Tienfala Gare, Noumoubougou, Fougadougou, Manambougou, and Djinkoni. This water is intended to meet the domestic needs (drinking, cooking, washing, watering animals, gardening, etc.) of the respective populations. Sampling points were chosen based on public water sources frequently used by the population. A collection of 16 domestic wells and 14 boreholes was thus carried out. Les échantillons d'eau destinés à l'analyse physicochimique (pH, température, conductivité, nitrites, nitrates, ammonium, Pb, Cd, Cu etc.) ont été prélevés dans des flacons en plastique d'une capacité de 1,5L chacun.

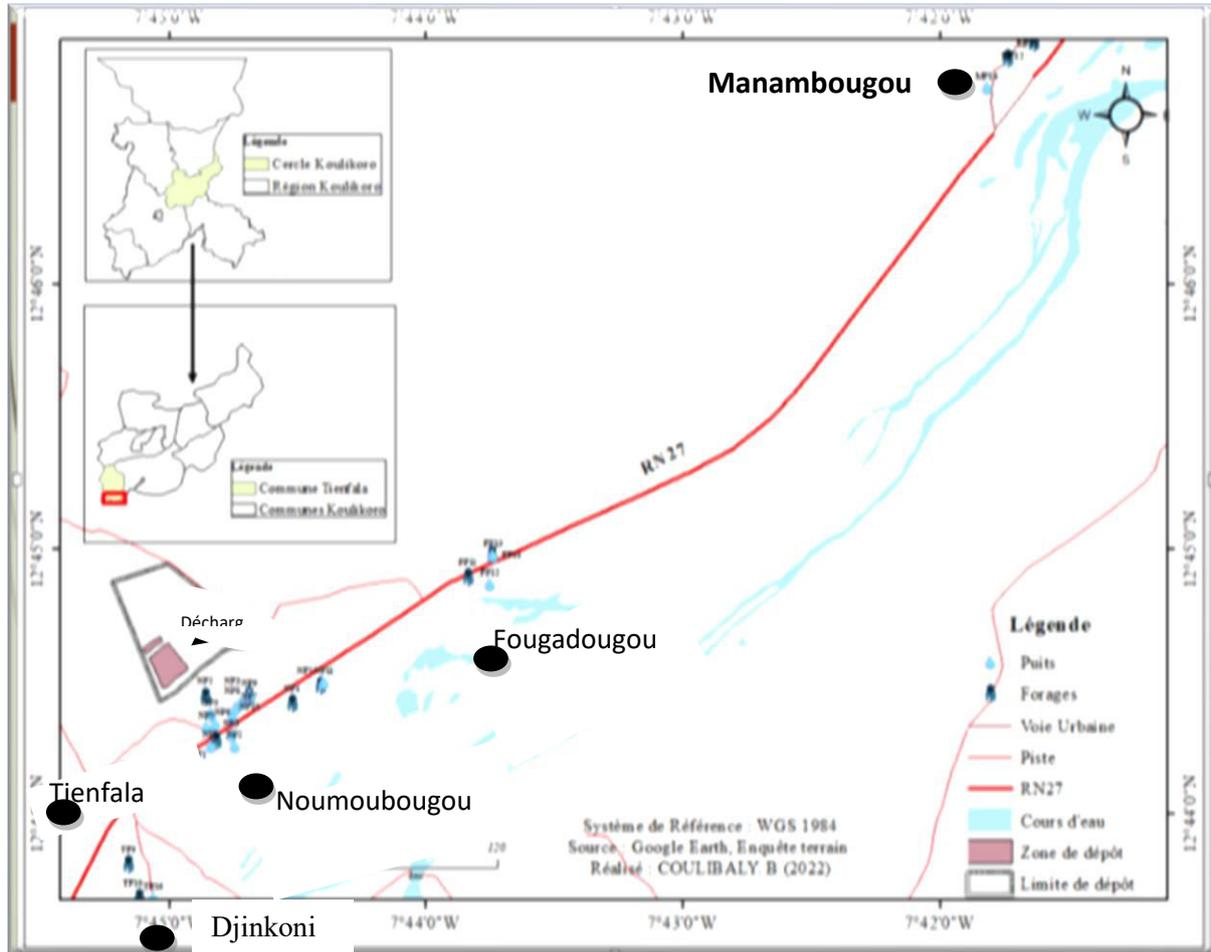


Figure 2: Water sampling from wells and boreholes in targeted villages, Tienfala commune, 2022

Sample Preparation

Each water sample collected was automatically coded using a referenced sampling form (date, location, number, time of collection). All samples were stored in a cooler containing pre-frozen dry ice. Upon arrival at the National Water Laboratory (LNE) in Bamako, all water samples were placed in the physicochemical analysis room before undergoing physicochemical analysis.

2.5. Sample Analysis

The in-situ analyses included measurements of pH, conductivity, and temperature (°C). These parameters were measured in the field using a multiparameter probe (WTW3630 ID SET F). Nitrite (NO₂⁻) and nitrate (NO₃⁻) concentrations were determined by ion chromatography (IC 881). Ammonium ion (NH₄⁺) concentrations were measured with a spectrophotometer (DR 6000 HACH) that absorbs at a wavelength of 425 nm in program 380. The concentrations of heavy metals (Ni, Cu, Cd, Hg, Ag, Fe, As, Pb and Cr⁶⁺) were measured using an ANALYTIKJENA ICP instrument. However, all samples intended for heavy metal analysis were first acidified with nitric acid (HNO₃-) (as a preservative at 2%) so that the dissolved metals would remain in ionic form, thus enabling their detection by the ICP instrument.

2.6. Ethical consideration: The study was authorized by community authorities and the anonymity of the owners of the water sources was observed.

III. RESULTATS

The domestic wells differ in their construction methods, depth, static water level, and water volume. During our field visits, we observed that all of these domestic wells and boreholes are at least 30 years old. They are generally public, individual, or semi-collective, and are scattered along both sides of the RN27 highway. On average, the static water level measured in all the domestic wells is 6.99 ± 1.41 meters. Generally, the depth of all these domestic wells varies from 3.68 to 11 meters. Based on visual observations made in the field, the majority of domestic wells are exposed to pollution linked to the numerous human activities (gardening, washing, market gardening, watering animals, etc.) carried out nearby. The boreholes in and around the village of Noumoubougou are adequately equipped and protected with hydrants fitted with hand pumps. The borehole depths vary between 50 and 180 meters.

Table I: Average results of physico-chemical analyses of water samples taken from the different underground sources which do not conform to the Malian drinking water standard.

Sample codes	PH	Temperature °C	Conductivity $\mu\text{S/cm}$	Nitrate mg/L	Nitrite mg/L	Azote Ammoniacal mg/L
NP1	5,43±0,3	29,57±0,4	73±8,7	9,12±0,8	0,023±0,008	0,06 ± 0,03
NP3	5,28±0,1	30,27±0,8	54,33±4,9	7,31 ±4,8	0,018±0,002	0,04±0,02
NP7	5,88±0,4	28,47±0,5	60,33±17,8	8,5±0,6	0,021±0,002	0,13±0,02
FP12	6,74±0,4	26,87±0,1	264,67±2,2	53,33±15,3	0,017±0,006	0,05±0,03
FP13	6,32±0,02	27,97±0,6	197,67±35,6	50,57±11,3	0,022±0,01	0,03±0,02
TP15	6,10±0,04	29,27±1,2	504,33±113,1	113,91±58,5	0,019±0,01	1,18±0,5
TF8	7,09±0,2	28,53±0,4	305,33±103,1	51,28±17,6	0,021±0,005	0,03±0,02
Malian Standard	5,5-9	40	1500	≤ 50	≤ 0,02	≤ 1

Of the 90 water samples analyzed, the average pH ranged from 5.43 to 7.09.

During the three sampling campaigns, the highest conductivity was observed at TP15 in March 2022 with 674 $\mu\text{S/cm}$ and the lowest at NP8 with 35 $\mu\text{S/cm}$.

3.1.2. Heavy metal (or trace metal, TME) results

The results of the analyses carried out on the metals (Ni, Cu, Cd, As, Cr, Hg, Ag, Fe and Pb) are shown (non-compliant) in Table 2 below.

Table II: Results of heavy metal analyses of groundwater from the village of Noumoubougou and surroundings (January-March 2022) with only positive samples.

Sample codes	Ni mg/L	Cu mg/L	Cd mg/L	As mg/L	Cr ⁶⁺ mg/L	Hg mg/L	Ag mg/L	Fe mg/L	Pb mg/L
NP5	< LD	< LD	< LD	< LD	< LD	< LD	< LD	0,434	< LD
NP6	0,05351	< LD	< LD	< LD	< LD	< LD	< LD	< LD	< LD
NP9	0,02109	< LD	< LD	< LD	< LD	< LD	< LD	< LD	< LD
TF7	< LD	< LD	< LD	< LD	< LD	< LD	< LD	0,301	< LD
Limit of detection (LOD) in mg/L	0,0002	0,0001	≤0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001
Malian standard	0,02	1	0,003	0,01	0,05	/	0,5	0,3	0,01

Average nitrate concentrations at certain points exceeding the Malian drinking water standard were measured at TP15 (113.91mg/L), FP13 (50.57mg/L), FP12 (53.33mg/L) and TF8 (51.28mg/L).

Detection Limits

The results of the various analyses showed that nickel and iron concentrations exceeded the Malian drinking water standard. These high concentrations were measured in samples NP6 and NP9 (Table 2). Similarly, iron(II) concentrations exceeding this standard were observed in samples NP5 and TF7. Overall, the majority of the heavy metal results are within acceptable limits of the drinking water standard.

IV. DISCUSSION

In this study, the water samples from the 16 domestic wells and 14 boreholes analyzed had an average temperature of 29°C. This result is comparable to those found by [17], and can be explained by the influence of ambient temperature on the water sampled and also by the fact that the groundwater in our study area is itself most often at a shallow depth.

The results of this study also showed that the majority of groundwater samples had an acidic pH, especially in the third sample taken in March 2022. These results are comparable to those found in a previous study conducted by PRUBA (2021) in the municipality of Tienfala, which showed that the pH of groundwater (boreholes and domestic wells) was generally below 7. However, they also remain less mineralized according to studies carried out by [17], where the conductivity varies from 60 $\mu\text{S}/\text{cm}$ to 1720 $\mu\text{S}/\text{cm}$. The domestic well located in Tienfala (TP15), the high concentration (113.91 mg/L) which exceeds twice the standard for nitrates, may be due to non-compliance with the distance between the domestic well and the latrine, but also to poor hygiene conditions around the said well, and also to surface runoff of wastewater.

According to studies conducted by [18], the poor water quality with respect to nitrates is due to nutrient pollution, the origin of which is probably linked to the oxidation of nitrites by nitrifying bacteria following wastewater infiltration. The observed clusters show that conductivity, temperature, and nitrogen content are higher in shallow wells [19]. These observations are consistent with those made in this study. This could explain the high concentrations of nitrates and nitrites found in the water from domestic wells (TP15, NP12, NP13, NP7, NP1, and FP13) and boreholes (TF8) in and around the village of Noumoubougou. Long-term exposure to nitrates can lead to adverse health effects such as headaches, stomach cramps, vomiting, or an increased heart rate [20]. They can cause a condition called "blue baby syndrome" (methemoglobinemia), which typically affects bottle-fed infants. All average values from some of the sampled waters met the Malian drinking water standard (≤ 50 mg/L) [2]. Indeed, the presence of nitrates in the water from the Tienfala Château borehole (TF8, 51.28 mg/L) can be explained by some of the factors we listed above. However, the results obtained in this study confirm those already found (155.86 mg/L) by PRUBA (2021), even though our values are lower. The average NH_4^+ contamination load in the different sources varies from 0.001 ± 0.5 to 1.1 ± 0.5 . The Tienfala well (TP15) had a higher average value (1.18 mg/L). However, the average ion concentration in the TP15 sample exceeded the permissible level for drinking water (<1 mg/L). Toure A, et al. 2017 [2] in Ségou, the average NH_4^+ contamination load was reported to vary from $0.25 \text{ mg/L} \pm 0.33 \text{ mg/L}$ in well water to $0.26 \text{ mg/L} \pm 0.22 \text{ mg/L}$ in borehole water, both lower than the guideline value. These high values could be explained by human activities and fecal pollution of animal origin. All the heavy metals studied (nickel, copper, cadmium, arsenic, chromium, mercury, silver, iron, lead) were present at levels below the Malian drinking water standard, as confirmed in 2020 by Daniel Abiriga et al., and below the Norwegian drinking water standards [21] with the exception of nickel and iron. Indeed, nickel concentrations were measured in domestic well water (NP9, 0.054 mg/L) and (NP6, 0.021 mg/L). Similarly, iron concentrations were measured in domestic well water (NP5, 0.434 mg/L) and water from a borehole at the Tienfala public school (TF7, 0.0301 mg/L). However, the concentrations of these two chemical elements were measured at values exceeding the drinking water standards applied in Mali. Furthermore, the absorption of significant quantities of nickel can have long-term adverse health consequences for the inhabitants of the village of Noumoubougou and surrounding areas, namely the development of lung, laryngeal, and prostate cancer [22].

Similarly, an excessive concentration of iron in drinking water will not only affect its taste but also contribute to a reddish color, leading to increased turbidity. Metals can be stored primarily in the bones, liver, kidneys, and brain. They disrupt ecosystems, degrade soils, water, forests, and crops, and accumulate in the food chain. Water is one of the most important natural resources, as no life can survive without it [23].

V. CONCLUSION

This research was conducted in the village of Noumoubougou and surrounding areas between January and March 2022. The results highlighted the poor physicochemical quality of the water consumed by the population from certain underground sources. This poor quality is generally due to high concentrations of nitrites, ammonium nitrate, nickel, and iron measured in water from domestic wells and boreholes. Therefore, based on all the results obtained, the groundwater in the village and surrounding areas exhibits at least one non-compliant physicochemical parameter. These results must be communicated to the population, raising their awareness of the risks.

REFERENCES

- [1] Ouiza Ould Ali. Impact of open dumps on the environmental quality of the Cheliff River (Algeria) Ouiza Ould Ali. Doctoral thesis, University of Alger. 2018: p193.
- [2] Toure A and al. Comparative Study of the Physicochemical Quality of Well, Borehole and River Water Consumed in the Commune of Pelengana in the Segou Region of Mali. JWA. 2017; 12(30): 449-458.
- [3] Kochetkova P. Daily air and water pollutants and their impact on health, IFA University, Paris, June 19, 2023. Accessed October 25, 2025. <https://www.carenly.com>
- [4] Paulin N'Guessan and al. Household perception of tap water quality in the Adjouffou, Gonzagueville and Anani districts in the municipality of Port-Bouet in Côte d'Ivoire. Int. J. Biol. Chem.Sci. February 2024;18(1): 289-302 <https://www.ajol.info>
- [5] Maoudo Hanne and al. Comparative study of the physicochemical quality of well and borehole water consumed in the commune of Sinthiou in the Tambacounda province, Senegal: LCPOAE, 2020.
- [6] Annie Locas. Microbiology of groundwater used as drinking water sources. INSPQ, Accessed 16/09/2025 on the website <https://www.inspq.qc.ca/bise/microbiologie-des-eaux-souterraines>
- [7] Kanownik G. P. Impact of small municipal solid waste landfill on groundwater quality Polongne. Springer nature Link. 2019; 191(169): 34-47
- [8] Laure M and al. One-third of the African population lacks access to drinking water: what structural solutions? December 18, 2018. Accessed November 12, 2025. Available at <https://link.springer.com>
- [9] IFAD. Drinking water: no saving is too small, India, 2019. Accessed October 12, 2025 on the <https://www.flickr.com>
- [10] Boubacar M. Surface water quality of the physico-chemical characterization area, spatio-temporal dynamics of suspended solids (SS) and fecal bacteria (E. coli) concentrations. Science de la Vie et de la Terre, Namay, March 31, 2023, p 23.
- [11] Taupin J. D. Study report on the Integrated and Sustainable Management of Aquifer Systems and Shared Basins in the Sahel Region, IAEA, Vienna, 2017. Accessed 12 October 2025. Available at <https://www.sciepub.com>
- [12] Map/INSTAT. Production of tons of solid waste in Bamako, Mali, August 5, 2019, p44
- [13] Gbamele kouassi serge and al. Evaluation of chemical contamination of groundwater by anthropogenic activities: case of the area of ity-floleu sub-prefecture of Zouan-Hounien, West of the Ivory Coast, 2020.
- [14] Espérance O, Hounsounou and al. Pollution of domestic water in disadvantaged urban areas of developing countries: Benin, 2016; p 2395.
- [15] Coordination Unit for the Preparation of the Bamako Urban Resilience Project/Ministry of Land Affairs, Urban Planning and Housing. Preliminary Environmental and Social Impact Assessment Report for the Construction of Sewage Sludge Treatment Plants in Tienfala and the Senou Airport Area, Bamako, Mali. 2021, p. 96.
- [16] Coumare K and al. QBacteriological quality of drinking water (boreholes and wells) in three districts of the Koulikoro region, Bamako, Mali. Rev. Mali Infeciol. June 9, 2018; 1(11): 18-24. Available at <https://revues.ml/index.php/remim/article/view/983>
- [17] Camara .o and al. Microbiological pollution of groundwater in the Tanghin Dieux district and perspectives in Ouagadougou. Environmental engineering thesis. International Institute for Water and Environmental Engineering. Burkina Faso, 2011, p 200. Available online CDI Foundation 2iE.
- [18] Abbou MB and al. Impact of leachate from the illegal landfill in the city of Taza on Morocco's water resources. International Science and Technology Conference. 2014; 4(2): 31-38
- [19] Ohou-Yao M. J. A , Séka A. M., Mambo V., Yapou O. B.,Konan K. F. Houéno P. C Contamination of traditional well water by nitrates in the Lobo watershed. Ivory Coast. 2014; 3(2): 12-20 .

- [20] Traoré O and al. Microbiological and physicochemical quality of groundwater and risk factors for its pollution in Ouagadougou, Burkina Faso. MDPI. August 29, 2023; 15(21): 34-37 <https://www.researchgate.net>
- [21] Daniel Abiriga and al. Groundwater contamination from a municipal landfill: effect of age, landfill closure, and season on groundwater chemistry. Norway. October 1, 2020; 737: 31-39
- [22] Lenntech. Chemical properties of nickel, impact of nickel on health - impact of nickel on the environment. Accessed on 16/09/2025 on the website <https://www.lenntech.fr/periodique/elements/ni.htm>
- [23] Raja Adzrin Raja Ahmad and al. Evaluation of domestic water use for good health and well-being, Indonesia, 2022.p 30. https://www.bps.go.id/tab_sub



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