IMPACT OF POLLUTION ON THE PHYSICAL, CHEMICAL, AND BACTERIOLOGICAL PARAMETERS OF DRINKING WATER FROM SEVERAL WELLS IN THE MUNICIPALITY OF KANKAN (GUINEA).

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Abstract

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The issue of access to drinking water is a major challenge, particularly in developing countries such as Guinea. That is why this study set out to examine the factors affecting the quality of drinking water from 20 unimproved wells in the Kankan region (Republic of Guinea). The study began with a survey of the environment surrounding the wells under investigation. Next, pH, temperature, and turbidity were determined according to standard NF T 90-008, while conductivity was determined according to standard NF EN 27888. Chlorides were measured by titrimetry, while major ions (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SO_4^{2-}) were quantified by molecular absorption spectrophotometry. The results obtained show that most wells are in a critical state of unsanitary conditions. Physicochemical analyses reveal that pH and turbidity, which vary from 4.986 to 7.624 and from 0.84 to 29.6 NTU, respectively, do not meet WHO standards in many cases. The levels of ammonium ions (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-) and sulfate ions (SO_4^{2-}) comply with WHO standards. However, phosphate ion (PO_4^{3-}) levels ranging from 0.24 to 9.81 mg/L do not meet the standards for many wells, while only one of the twenty wells has a chloride (Cl^-) level of 255.31, which is above the WHO standard. Bacteriological parameters indicate that several wells are contaminated, mainly by total coliforms. The poor water quality of some wells could be correlated with their unsanitary condition.

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Introduction:

Water is essential to life, and all people must have access to a satisfactory water supply (sufficient, safe and accessible). Better access to safe drinking water can translate into tangible health benefits. (WHO, 2017). The importance of water, sanitation and hygiene for health and development is reflected in the conclusions of a series of international political forums, such as the World Water Conference in Mar del Plata (Argentina), the Millennium Development Goals, adopted by the United Nations (UN) General Assembly in 2000 (Sokegbe, et al., 2017)

In Africa, many countries do not have access to drinking water, despite the fact that access to this important resource is essential for the survival of populations, but poses serious problems (Yaka et al., 2020). This situation could be explained by growing urbanization in African cities, demographic pressure linked to economic development and climate change (CAWST, 2013). Guinea, like other African countries, continues to face this problem despite being the water tower of West Africa, with high rainfall estimated at 405.91 km3on average per year. In Guinea, there is a marked disparity between rural and urban areas. Access to drinking water is 72% in urban areas, compared with 67% in rural areas (Sagno 2023). Unprotected wells or undeveloped springs continue to be an important source of water supply, even in urban areas (10.3%). In poor urban areas, this mode of water supply concerns 17.2% of households (MEEF, 2016). The city of Kankan, Guinea's 2ndthlargest city, is among those most affected by this phenomenon. While these wells have the advantage of solving the problem of water availability, the quality of this

commodity is often not guaranteed. It can be a source of diseases such as cholera, typhoid fever, diarrhoea, bilharzia and many others, due to its contamination by household, industrial and agricultural waste, excreta and various organic wastes. Indeed, various studies have highlighted the pollution of well water by microorganisms (Hounsinou et al., 2015; Karambiri et al., 2023).
Thus, achieving goal number VI, of sustainable development 2016-2030 inteded to ensure access to water and sanitation for all and ensure management of water resources, requires ongoing assessments of drinking water quality (Coumare et al., 2018). It is for this reason that the present study sets out to assess the physicochemical and microbiological qualities of a few wells in the city of Kankan

Materials and methods

Presentation of the study area

The city of Kankan, made up of 27 districts, is located in the heart of Upper Guinea, between 10° 18' and 10° 23' north latitude and between 9° 21' and 9° 11' west longitude, and covers an area of 46.45 km^2. The climate is dry tropical (or "South Sudanian"). The year comprises two main seasons. The dry season extends from November to April. During this period, a dry wind laden with fine dust (Harmattan) blows irregularly. The rainy season begins in May and ends in October. Average annual rainfall is 1,534 mm. The temperature varies between 25°C and 35°C, sometimes reaching 40°C in March (Condé, 2018).

Sampling

Sampling was carried out on water from twenty (20) traditional wells located in several localities of the city, both in the town center and in the outlying districts of Kankan. All samples were taken using wells found on site in September 2020, then poured into sterile, labelled one-litre bottles before being sent to the laboratory for analysis.
In situ analyses were carried out for pH, temperature and turbidity, using a pH meter and turbidimeter respectively. In order to maintain their original quality, the water samples were sent directly to the water quality analysis laboratory.

Determination of physicochemical parameters

The pH, temperature and turbidity of the samples were measured in situ using measuring equipment. pH and temperature were measured using a 9310 IDS multi-parameter, while turbidity was determined using a TB210IR turbidity meter in accordance with standard NF T 90-008; 2001. A Multi3420 multi-parameter instrument was used to determine water conductivity in accordance with NF EN 27888. Chlorides were determined by titrimetry, while major ions (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SO_4^{2-}) were quantified in samples from different wells by molecular absorption spectrophotometry using a Palintest 7100 photometer based on the method proposed by Karambiri et al, (2023).

Determination of bacteriological parameters

The bacteriological parameters determined during the course of the work were essentially total coliforms and faecal coliforms. These bacteria were identified and counted using the membrane filtration method, which involves passing 100 ml of well water over a membrane with a pore diameter of 0.45 µm. The membranes were then placed on selective media for 48 hours at 37°C in an oven. Chromocult coliform culture medium was used for the determination of total and faecal coliforms (Karambiri et al., 2023).

Results and discussion

Environmental characteristics of traditional wells in Kankan

Table 1 presents the environmental conditions of the wells included in this study. Analysis of this table shows that the surroundings of several of the wells studied are polluted due to the failure of certain families to observe hygienic rules (presence of garbage around the well, lack of cover and coping, poorly maintained wells, etc.). Wells PK1, PK2, PKK2, PB2 and PBO1 are particularly polluted, either due to the presence of garbage, stagnant well water, toilets or cesspools in their vicinity, or due to the fact that they are generally uncovered and unlined. An immediate consequence of this state of pollution is that wells PKK2, PBO1 and many others present an odor and taste contrary to the WHO recommendation that water should be free from tastes and odors unpleasant to consumers (WHO, 2017). In addition, the survey revealed that 12 of the 20 wells are not disinfected at all, even though disinfection is an effective barrier against many pathogens when treating drinking water. It must be practiced on surface water and groundwater susceptible to faecal contamination (WHO, 2017). Several of the wells in this study are located less than 15 m from a well or latrine, contrary to the standard recommended by the WHO (Karambiri et al., 2023). In view of the above information, it can be said that well water contamination is easily caused by families' failure to observe hygienic measures. In fact, the most recognized factors of well pollution are the presence of septic tanks and the lack of sanitary facilities.

Table 1: Environmental quality of wells surveyed

Neighbor hoods	Wells	Description of well environment
Dalako	PD1	No garbage around the well, well maintained; well without coping and located more than 15m upstream from the traditional latrine.
	PD2	Well located downstream from the traditional latrine, without coping, without cover, but well-maintained sump.
Timbo	PT1	Latrine located downstream and less than 15m from the well. Well with wooden lid, no coping, no garbage and no stagnant water around.
	PT2	Well water has taste and odor. This well has no cover or coping and is far from the latrine. No garbage or stagnant water, but also located downstream from the traditional latrine.
Madina	PM1	Well-maintained pit, no garbage or standing water near the well. This well is located upstream and more than 15m from the latrine. It is uncovered and has no curbstone.
	PM2	No coping and the well is badly maintained. In the vicinity of this well, there is no stagnant water, only garbage. The well is located downstream of the traditional latrine and more than 15m from it.
Kabada	PK1	Garbage and stagnant water near the well, without cover or curbstone. Well far from the improved latrine and upstream from it, but its water has a smell and taste.
	PK2	Garbage but no standing water. Poorly maintained pit; well without coping, located downstream and less than 15m from the concrete latrine.
Kankankoura	PKK1	Well with no cover or coping, and no garbage in the vicinity. This well is located more than 15m from the family latrine. The well is dirty.

	PKK2	No garbage, no stagnant water; well with inadequate cover, no coping, with a well-maintained sump, but also located downstream and less than 15m from the latrine. This water sometimes tastes bad.
Energy	PE	Well without cover, without coping with colored water and located less than 15m from the traditional latrine. No garbage or stagnant water, with a poorly maintained well.
Banankoroda	PB1	Odorless, colorless water used for housework and bathing. The well has no coping and is located upstream from a traditional latrine. It has a maintained male well.
	PB2	We noted the proximity of this well to the sump, the absence of a coping and the taste of its water. This well is far from the latrine, but located downstream. The well is well maintained and there is no smell.
Korialen	PKO1	The well water tastes and smells good. This well, although covered, has no curbstone, is far from the latrine, has no garbage or stagnant water around it, but is located downstream from the traditional latrine.
	PKO2	Located upstream from a traditional latrine, this well's environment is appreciable.
Bordeau	PBO1	Garbage and stagnant water in the vicinity of a well with no curbstone or cover. Well very far from the improved latrine but downstream from it, and its water has a smell and taste.
	PBO2	This water is used for all purposes, including drinking, because it is treated with chemicals. Although the surrounding area is clean and the pit well maintained, the well has no coping and no suitable cover.
Hèrèmakono	PH1	Covered well, no coping, turbid water and located less than 15m from the traditional latrine. Absence of garbage and stagnant water, presence of a poorly maintained well.
	PH2	With taste and odor, almost without cover or coping, well-maintained sump, latrine close to and downstream from the well.
M'balia (Farakô 2)	PM	Well almost uncovered, without coping, but clean surroundings, far from the latrine.

Physico-chemical characteristics of surveyed well water

The physico-chemical characteristics of the water in the 20 wells studied are shown in Table 2. The results show that well water temperatures ranged from 25.3 to 26.3°C. These temperatures are all slightly above the WHO standard set at 25°C, but acceptable for arid and semi-arid zones (Ould Cheikh et *al*., 2025). As for pH, it ranges from 4.986

to 7.690. Wells PKK1, PBO1, PH1, PH2 and PM have a very acid pH with values of 4.986, 5.970, 5.260, 5.655 and 5.58 respectively, not meeting WHO standards which stipulate that the pH of drinking water should be between 6.5-8.5 (WHO, 2017). The pH of water can influence its physical, chemical and bacteriological characteristics. Acidic water can mobilize certain metals from soil and piping systems, increasing their bioavailability and changing their toxicity. The change in toxicity caused by a pH variation is, however, specific to each metal and organism (Fedoua and Rym, 2018). Bengaly, (2016) found similar pH values ranging from 5.01 to 8.23 on well water in Bamako (Mali), while Sawadogo et al., (2023) found pH values of 6.05 to 7.35 for well water in Ouagadougou (Burkina Faso). According to Bah et al. (2024), well water in Rotama, a commune of Conakry (Guinea), has an acid pH ranging from 5.56 to 6.89.

Turbidity in the well water studied ranged from 0.84 to 29.6 NTU. According to WHO standards, the turbidity of drinking water should be less than 5 NTU. On this basis, we can say that water from wells PD1, PD2, PM1, PM2 and PKK2, with turbidities of 13.4, 27.8, 8.26, 8.39 and 29.6 NTU respectively, does not comply with standards. This could be explained by the absence of magelle in all these wells. These wells should be treated to reduce turbidity, as suspended particles render water disinfection ineffective by absorbing microorganisms, thus preventing chlorine from neutralizing them (LeChevallier et al., 1981). Turbidity is due to the presence of suspended particles, particularly colloidal ones, which are the basis of water color. Cornec (2005) has shown that turbidity has a negative impact on water quality parameters, and consequently on health. Indeed, suspended elements in water are sources of refuge for pathogenic bacteria (Cornec, 2005). As for conductivity, it varies between 80.1 and 1162 µS/cm. According to WHO standards, the conductivity of drinking water should be less than 2,500 µS/cm. Sawadogo et al. (2023) found conductivities ranging from 217 to 669 µS/cm in borehole water in Ouagadougou, Burkina Faso. Bah et al. (2024) found lower conductivities ranging from 57 to 208 µS/cm in borehole water at Rotama (Guinea). This result could be explained by soil quality, as conductivity is dependent on the mineralogical composition of the soil, and thus high conductivity may be a sign of heavy metal contamination (Rodier et al., (1996).

Table 2: Physico-chemical parameters of well water studied

Well	**Parameters**			
	Temperature (°C)	**pH**	**Turbidity (NTU)**	**Conductivity (µS/cm)**
PD1	26.20	6.611	13.40	271.0
PD2	25.90	6.408	27.80	223.0
PT1	26.30	7.453	1.23	791.0
PT2	25.90	7.476	1.62	886.0
PM1	25.90	6.582	8.26	157.2
PM2	26.20	6.742	8.39	219.0
PK1	25.90	7.550	2.29	932.0
PK2	26.00	7.624	0.84	969.0
PKK1	26.1	4.986	1.70	601.0
PKK2	25.9	7.690	29.60	433.0
PE	26.3	6.642	1.63	288.0
PB1	25.9	7.508	1.00	1162.0
PB2	25.9	7.252	0.93	1026.0
PKO1	25.8	6.603	1.53	578.0

PKO2	25.6	6.797	1.60	254.0
PBO1	25.4	5.970	1.70	80.1
PBO2	25.6	6.282	1.68	28.7
PH1	25.3	5.260	1.60	620.0
PH2	25.3	5.655	2.18	476.0
PM	25.5	5.580	1.28	254.0
WHO standard (2017)	**25°C**	**6,500-8,500**	**≤ 5 NTU**	**-**

Chemical characteristics of studied well water

Table 3 shows the results for the chemical parameters of the well water studied. Analysis of this table shows that Nitrate (NO_3^-), Ammonium (NH_4^+) and Sulfate (SO_4^{2-}) levels comply with WHO standards for all the wells studied.

In fact, the nitrate content, ranging from trace levels to 6.6 mg/L, is well below the WHO standard of 50 mg/L. This is salutary, as nitrates, although not a priori a problem for human health, are capable of transforming into nitrites in the body, and the latter are harmful to the organism, particularly for infants (M'Baye et al., 2019; Ouedghiri et al., 2014). The work of Gbohaida et al. (2016) in Benin and M'Baye et al. (2019) in Mauritania, which revealed nitrate levels ranging from 5.28 to 10.56 mg/L and 0.1 to 78 mg/L respectively, are higher than those found in the present study. Nitrite (NO_2^-) content ranged from 0.00 mg/L to 0.12 mg/L, whereas WHO standards stipulate a maximum nitrite ion content of less than 2.0 mg/L. Nitrite levels are generally slightly higher than those found by Sawadogo et al (2023), which ranged from 0.002 to 0.011 mg/L in Ouagadougou (Burkina Faso), but close to those found by Hane et al (2020), who obtained a mean nitrite level equal to 0.06 ± 0.07 mg/L in Sinthiou (Mali).

Ammonium ions (NH_4^+) were found in trace amounts in all the water samples analyzed, while sulfate ion levels remained below 250 mg/L, in line with WHO standards. Sawadogo et al (2023) found similar results for well and borehole water in Burkina Faso, with concentrations ranging from 0.005 to 0.12 mg/L. Sulfate ion (SO_4^{2-}) levels in all the well waters studied were also below 250 mg/L, in line with WHO (2017) recommendations.

On the other hand, the concentration of phosphate ion (PO_4^{3-}), ranging from 0.24 to 9.81 mg/L, did not meet the WHO standards of less than 1 mg/L in the vast majority of wells evaluated. Phosphates are naturally present in the soil, but their main source in groundwater is agricultural activities (leaching and infiltration) (Azanga et al., 2016). High phosphate levels can contribute to turbidity problems associated with water greening (eutrophication) (Sawadogo et al., 2023). In their study of borehole water from the Ouagadougou commune, Sawadogo et al. (2023) obtained lower phosphate levels, ranging from 0.17 to 0.72 mg/L. As for chloride ion content, only well PKK1, with a chloride concentration of 255 mg/L, slightly exceeds the WHO concentration limit of 250 mg/L. Chlorides have no effect on consumer health, as their concentrations in the body are regulated by a complex system involving both the nervous and hormonal systems. Even after the absorption of significant amounts of chlorides through water and food, chloride balance is maintained mainly through the excretion of excess in the urine (Sawadogo et al., 2023). Bengaly, (2016) found chloride ion levels lower than those in Kankan water, ranging from 3.13 to 117.35 mg/L in borehole water and 1.85 to 385.01 mg/L in well water in Bamako (Mali). Sawadogo et al (2023) found even lower values, ranging from 0.7 to 10.5 mg/L.

Table 3: Chemical parameters of well water studied

Well	**Concentration (mg/L)**

	Nitrate (NO_3^-)	**Nitrite** (NO_2^-)	**Ammonium** (NH_4^+)	**Phosphate** (PO_4^{3-})	**Chloride** (Cl^-)	**Sulfate** (SO_4^{2-})
PD1	6.6	0.02	<<	0.55	83.425	<200
PD2	0.08	0.08	<<	0.64	67.45	<200
PT1	<<	0.03	<<	0.94	127.8	<200
PT2	<<	0.02	<<	1.10	138.47	<200
PM1	2.90	0.04	<<	2.80	56.8	<200
PM2	0.04	0.02	<<	0.37	51.475	<200
PK1	3.30	0.04	<<	0.77	140.225	<200
PK2	<<	0.12	<<	1.30	142.00	<200
PKK1	<<	0.00	<<	0.44	255.31	<200
PKK2	2.20	0.07	<<	0.65	47.925	<200
PE	<<	0.01	<<	981	62.125	<200
PB1	2.4	0.00	<<	0.96	170.4	<200
PB2	<<	0.07	<<	1.45	143.775	<200
PKO1	<<	0.03	<<	1.30	71.00	<200
PKO2	<<	0.02	<<	0.53	55.025	<200
PBO1	2.60	0.05	<<	0.65	71.00	<200
PBO2	2.30	0.02	<<	0.24	99.40	<200
PH1	2.20	0.03	<<	0.47	212.76	<200
PH2	3.20	0.02	<<	3.10	191.48	<200
PM	2.20	0.01	<<	0.46	127.80	<200
WHO standard (2017)	50 mg/L	0.1 mg/L	0.5 mg/L	0.5 mg/L	≤ 250 mg/L	≤ 250 mg/L

<< : Trace

Bacteriological status of water from surveyed wells

Table 4 shows the bacteriological parameters of the water from the 20 wells analyzed. It can be seen from this table that only wells PK2, PKK1, PE, PB2, PKO1, PKO, PBO2, PH1, PH2 are free of any bacteriological contamination and therefore comply with the WHO standard (2017), which stipulates that total and faecal coliforms must be absent in drinking water. The other wells that do not comply with the standards have the highest turbidities. Overall, 55%

of wells are contaminated with total coliforms, while 10% are contaminated with fecal coliforms. These results differ from those obtained by Karambiri et al (2023), who found very high faecal contamination, i.e. 100% total coliforms and 86.48% faecal coliforms in well water at Dédougou (Burkina faso). Apart from this, the results obtained could be explained by a lack of treatment of the wells concerned. Well PK1, with a total coliform count in excess of 100 col/100 mL, is located in a highly polluted environment. Such a well is a potential health hazard for consumers. When drinking water is contaminated with pathogenic microorganisms, it can lead to the development of health problems in some consumers (Cornec, 2005).

The high level of contamination observed in well water could be due in part to the failure to respect the distance between the well and the latrine, or to the infiltration of surface water and the lack of maintenance of these wells, given that the majority of wells are built without curbstones or covers, and run-off water carrying various types of waste (faecal matter) is easily discharged into them (Karambiri et al., 2023).

Table 4: Bacteriological parameters of well water studied

Well	**Parameters**	
	Total coliforms (col/100 mL)	**Fecal coliforms (col/100 mL)**
PD1	**05**	**00**
PD2	**07**	**00**
PT1	03	00
PT2	**11**	**00**
PM1	22	00
PM2	12	00
PK1	**>100**	**00**
PK2	00	00
PKK1	00	00
PKK2	24	00
PE	00	00
PB1	**08**	**01**
PB2	00	00
PKO1	00	00
PKO2	00	00
PBO1	**16**	**01**
PBO2	00	00
PH1	00	00
PH2	00	00
PM	04	00
WHO standard (2017)	**Not detectable in 100 mL sample (col/100 mL)**	**Not detectable in 100 mL sample (col/100 mL)**

Conclusion

In the light of the results obtained from the assessment of the pollution status of traditional well water in the commune of Kankan, we can say that some of the well water investigated is polluted due to the excessive presence of physicochemical substances and bacteriological germs caused by natural phenomena and human activity, among other factors. In view of the investigations carried out in the field, there is sometimes a link between the unhealthiness of the well environment and the tests carried out in the laboratory. Consequently, it is imperative that appropriate measures be taken to maintain wells, as it is not only a question of setting up drinking water supply structures, but also of placing particular emphasis on the observance of hygiene rules.

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