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Physicochemical and metal quality evaluation of the ground water of the chief town of Sinthiou Maléme Commune in Tambacounda (Senegal)

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In underdeveloped countries, particularly, medium rural areas, the subsoil waters constitute an invaluable resource. However, they remain fragile and vulnerable because of demographic pressure, uncontrolled exploitation of discharges, and absence of adequate cleansing system and husbandries. This present work aims to evaluate the physicochemical and metal quality waters of 10 wells collecting the ground water of Sinthiou Maléme commune. Results obtained by the spectrophotometric method showed that the waters are moderately mineralized, soft and acidic. Their average contents of salts (fluorides, chlorides and sulphates), minerals (calcium and magnesium) and nitrogen (ammonium, nitrites and nitrates) vary but remain in the optimum level recommended by WHO for drinking. It also revealed the presence and state of certain trace elements such as iron, copper and zinc. However, the parameters such as chromium hexavalent and phosphates ions respectively make these subsoil waters non- drinkable water. Thus, the development of a method for the efficient removal of hexavalent chromium in these waters is imperative.

Key words: Underground, wells, spectrophotometric, chromium hexavalent, phosphates, trace elements.

INTRODUCTION

In Senegal, particularly the rural medium area of the commune of Sinthiou Maléme, waters of well are considered as essential resources for agro-pastoral activities and drinking water in several households. These wells capture the water table which is subject to significant pollution of anthropogenic origin due to agricultural activities, anarchic occupation of space and lack of an adequate sanitation system (Ahoussi et al., 2010; Hounsou et al., 2010). In fact, the dominant economic activity in Sinthiou Maléme remains agriculture. The rate of access to the individual cleansing system is only 10% (PLHA, 2007). This locality has only traditional pit latrines. The commune is also disadvantaged because it lacks an evacuation system for disposing solid waste leading to the wild deposal of refuse in several places. These result in the spread of various pollutants (chemical,

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physical, metal and microbiological) in the underground table water which can likely modify the physico-chemical and metal composition of the water (Kanohin et al., 2017; Yapo et al., 2010; Ouandaogo-Yameogo, 2008). In addition, the acceptability of the water intended for consumption in this locality is generally based on its smell, color and flavor. However, good water should not only be drinkable, but must also meet certain physico-chemical, metal and bacteriological criteria that are well defined; it should be consumed without any notable health risk for its consumers throughout their lives (WHO, 2004). The present study aims to evaluate the physicochemical and metal quality of the well water consumed by the populations of Sinthiou Maléme in Tambacounda, Senegal. It will allow to see if the population that consumes this water run the risk of having water-borne diseases, such as diarrhea, cholera, typhoid, dysentery and other diseases due to the chemical composition of the water (fluorosis, lead poisoning, methemoglobinemia etc) in order to remedy it.

MATERIALS AND METHODS

Study site

The study was carried out in the chief town of the commune of Sinthiou Maléme. It is bordered in the North-West by the rural Community of Koussanar, in the South by the rural Communities of Ndoga Babacar, Maka Coulibantang and Nétéboulou, and in the East by the rural Communities of Koulor, Nétéboulou and Kothiary (Department of Bakel) (Figure 1). The commune (1349' 0 "N and 1355' 0" W) is located in the area of Tambacounda, Eastern part of Senegal. The climate is of soudano-sahélien type, characterized by two seasons: one rainy season and a dry season with a pluviometer varying between 600 to 800 mm. The dominant grounds remain the ferruginous grounds (laterites) and the depths of the ground water oscillate between 35 and 40 m (Kanfany, 2009).

According to the data provided by the local plan of hydraulics and cleansing of the rural community of Sinthiou Maléme, the population was estimated in 2006 at 20357 with a density of 16.86 inhabitants/km^2. Thus, the population is distributed on various villages but the density is much more significant on the level of the chief town because of the presence of the weekly market commonly called "Louma˝. The principal sources of pollution of the table water in this zone are the domestic, agricultural activities (infiltration of manures and pesticides) and pastorals (decomposition followed by the infiltration of the excrements).

Sampling

Sampling was carried out in a completely randomized design (Maoudombaye et al., 2016). On the whole, 10 domestic wells without cover were sampled (Figure 1) out of a total of 40 wells. The depth of the wells lay between 13 and 17 m with an average of 15.2 m curbstones varying between 90 and 100 cm. These wells are consumed by the majority of the populations. The samples were put in bottles and placed inside 500 ml polyethylene bag. Then they were sterilized, washed several times with water of the wells to analyze them and then they were closed hermetically. These water samples were carefully labelled and transported in a refrigerator at 4°C (Rodier et al., 2009) to the Department of Chemistry, University Cheikh Anta Diop, Dakar for organic and environmental analysis.

Measurement of physicochemical and metallic parameters

The physical parameters (pH and conductivity) are measured using a combined pH meter called HANNA instruments pH/conductivity HI. For the measurement of the pH, the apparatus was calibrated with buffer solutions pH = 7.01 then pH = 4.01. First, the pH mode is selected with the SET/HOLD button, after which the electrode is immersed in the sampled water. Finally, we waited a few seconds for the stability symbol at the top of the LCD to disappear and read the pH value displayed. For the conductivity, the apparatus was calibrated by immersing the probe in the clean calibration solution HI 7031 (1413 µS/cm). EC mode is selected with the SET/HOLD button and then the same procedure for pH is used. Plastic beakers are often used to minimize the electromagnetic interference. The hardness is measured by a colorimetric proportioning used to pour the sample into the tube up to the acceptable mark; then two drops of H 20 F color indicator were added. The reagent is withdrawn using a syringe set to zero; then it was poured drop by drop until the color changed (green coloring). At the end, the hardness is read on the syringe in mmol/L or in German degree (°d), then it is converted into French degree (°f) by multiplying with the factor, 1.78. The chemical and metallic parameters were measured by UV-visible spectrophotometry using a PF-11 round-cell photometer.

Analysis of samples by photometry

The water used for the sample to be analyzed was without the standard solutions of the reagents. The sample to be analyzed was prepared by adding reagents in 5 mL of water samples taken. It was very important to respect the order and time prescribed in the analysis protocol to ensure the reaction of the reagents with the analytics.

Principle of the analysis

The device was turned on, and the mode indicated (Visocolor, Visocolor Eco or nanocolor) in the protocol was chosen including the number of the filter to dose the element. The filter numbers were between 1 and 6 and each corresponds to a wavelength. The zero of the concentration was set before each determination to establish a zero reference for the measurement. To do this, the white tube was placed in the measuring well and the button was pressed to null zero. The photometer displayed zero and then indicates the sample was ready for analysis. The ready sample was placed in the measurement well and the M key was placed directly to obtain the concentration of the sample on the meter screen in mg/L.

RESULTS AND DISCUSSION

Parameters *in-situ*

Table 1 presents the minimal values (Min), averages (Moy) and maximum (max) values of the results of the physicochemical and metal analyses obtained in the whole wells, including the standard deviations of the 10 wells collecting groundwater in the study area. The values of Electric Conductivity (EC) and the Total of the Dissolved Solids (TDS) are 106 to 359 µS/cm with an average of 237.59 µS/cm and 56 to 171 ppm with an average of 119.5 ppm.

Electrical conductivity and TDS reflect the presence of

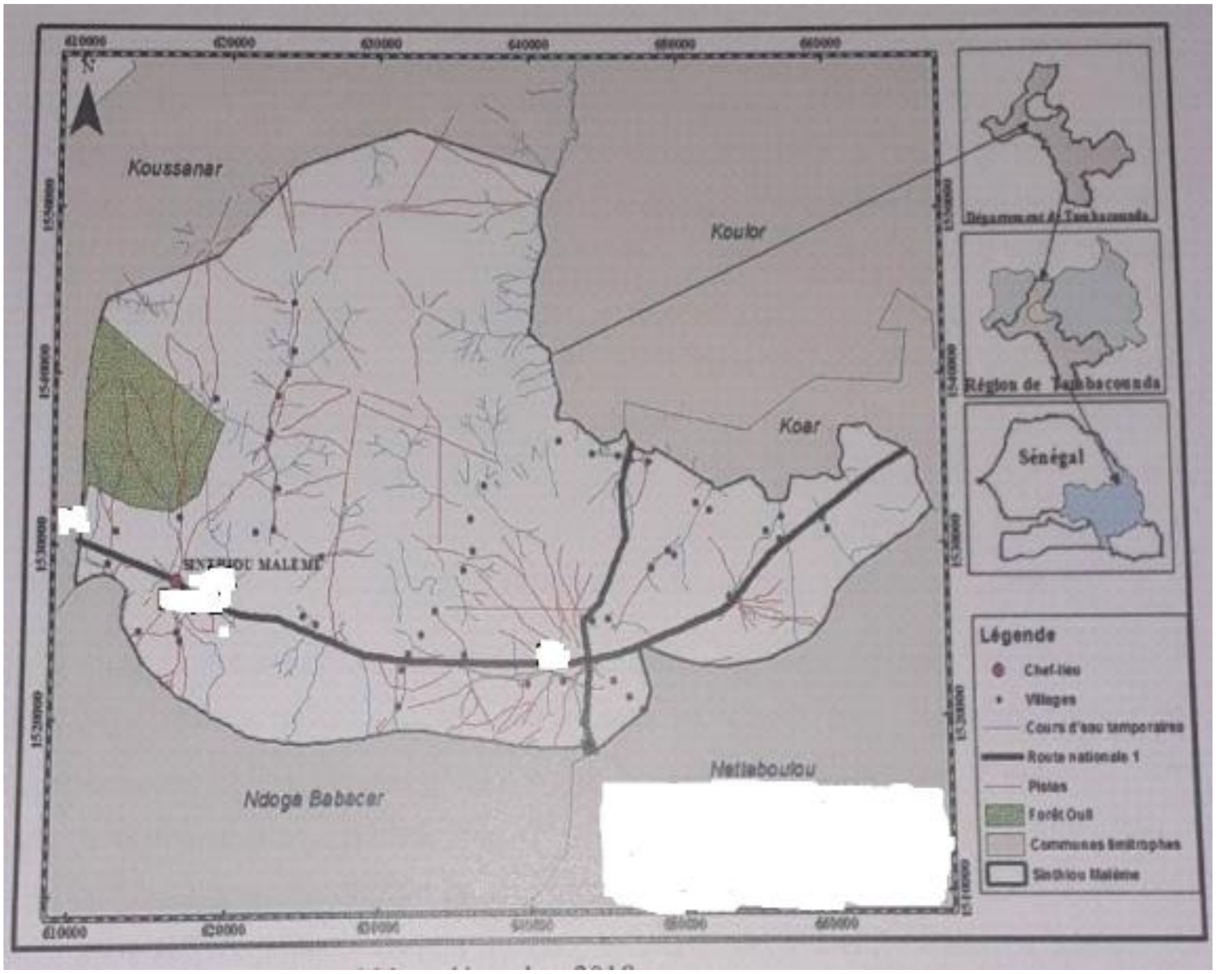

Figure 1. localization of the zone of study.

Table 1. Physicochemical and metal properties of water of wells.

Parameter	Max	Min	Moy	Standard deviation	Standards WHO
EC (µS/cm)	359	106	237.59	67.24	2000
TDS (ppm)	171	56	119.5	34.68	500
pH	7.58	5.81	6.68	0.57	6.5-8.5
TH (°f)	13	3.5	6.75	2.78	20
F - (mg/L)	1.3	< 0.1	0.61	0.35	1.5
Cl - (mg/L)	35	< 1	14.56	9.54	250
SO42- (mg/L)	72	< 20	38.11	17.92	250
PO43-(mg/L)	7.1	1	3.09	2.18	0.5
Ca2+ (mg/L)	71.12	7.12	32.70	16.33	100
Mg2+ (mg/L)	19.22	2.14	6.02	5.18	150
NH4+ (mg/L)	1.2	< 0.1	0.31	0.31	0.5
NO2- (mg/L)	0.27	0.02	0.14	0.09	3
NO3 - (mg/L)	91	< 4	34.87	30.77	50
Fe2+ (mg/L)	0.62	< 0.04	0.28	0.15	0.3
Cu2+ (mg/L)	0.3	< 0.2	0.22	0.04	2
Cr6+ (mg/L)	0.48	0.05	0.14	0.09	0.05
Zn (mg/L)	0.2	< 0.1	0.15	0.05	3

dissolved matter in water. Thus, we generally observed that the ground water of this zone is not very mineralized and that electric conductivity and the TDS are in perfect correlation. This could result in the low depths of wells (Sandao et al., 2018). In addition, a significant variation of conductivity is noted and TDS, with standard deviations of 67.24 µS/cm and 34.68 ppm. These variations could be related to the diversity of the probable geochemical processes responsible for the mineralization and salinization of this water. Failure to cover wells (open pit) could promote dissolution of solids from dust. However, these values are in phase with the WHO standards.

The pH of water tells us about the alkalinity or acidity of the water. An underground water having a low pH can indicate the presence of a pollutant on the table water level (Matini et al., 2009). Table 1 shows that the pH of this table water varies between 5.81 and 7.58 with an average of 6.68, and standard deviation of 0.57. These values show this water has slight tendency to be acidic. This acidity is probably related to the correlation between free CO2 and the rainwater which forms carbonic acid, reducing the pH of the water (Issa et al., 2020). The free CO_2 coming from the decomposition of the organic matter present in the ground or air would be considerable on the acidity of these water. However these waters remain within the acceptability level of WHO.

Minerals

Analysis of the table water shows that the water of the wells of this locality is not hard compared to the standards of WHO; its values oscillate between 3.5 and 13 °f with an average of 6.75 °f. The hardness (TH) of water generally indicates its contents of calcium (Ca2+) and magnesium (Mg2+) ions, which mainly results from the dissolution of limestone and dolomitic rock formation. These values are in line with the low levels compared to WHO standards for calcium and magnesium in these ground waters. However, these waters do not turn out to be dangerous for the health of consumers, but they cause scaling of the containers or interfere with domestic washing operations. Dimé et al. (2018) reported similar calcium and magnesium contents in characterizing the ground water located in a zone (municipality of Ngoundiane, Senegal) with strong industrial pollution.

Salts

The contents of salts such as fluoride, chloride and sulphate vary in water of this ground water. Their average values oscillate respectively between < 0.1 and 1.3 mg/L with an average of 0.61 ± 0.35 mg/L for fluorides; <1 and 35 mg/L with an average of 14.56 ± 9.54 mg/L for chlorides and < 20 and 72 mg/L with an average of 38.11 ± 17.92 mg/L for sulphates (Table 1). Furthermore, these results are in line with the value guide of WHO. However, the presence of the ion fluorides and chlorides in water must be controlled since they can cause medical disorders (Beaudoin, 2012) in particular dental fluorosis, cause unpleasant taste of drinking water and make it corrosive to pipe. The values obtained here are similar to those obtained by Gbohaida et al. (2016).

Nitrogen and phosphate

For the ground water of this locality, the average contents (0.31 ± 0.31 mg/L for ammonium; 0.14 ± 0.09 mg/L for nitrites and 34.87 ± 30.77 mg/L for nitrates) in nitrogen compounds are relatively high except ion nitrites (Table 1). The fairly high levels of nitrates and ammonium observed in these waters allow secondary inputs of anthropogenic origin. Indeed, Aulagnier and Vittecoq, (2007) and Klopp (2003) revealed that nitrate contents are higher than 10 mg/L in the water used for consumption which could reflect a contamination of anthropic origin. Otherwise, the low depth of the wells, the lack of hygiene (domestic wells not far from the latrines) and the agricultural and domestic activities (returns of used water and agricultural water, deposit of solid waste) would be the origin of the nitrogen pollution of water used for consumption. Concerning phosphate, as there are no industries that exploit phosphate in the zone, its high levels observed in the well water could be from the dissolution of chemical fertilizers or phosphate pesticides, which are pollution of agricultural origin (Touati et al., 2018). The Intrusion of the ground water, discharge of domestic wastewater and also the proximity of the latrines to the wells influence the contribution of phosphates in water. However the water of this locality has phosphate contents higher than the acceptable maximum value (Table 1) fixed by WHO. This could promote the development of algae (eutrophication) in the water after a few days of conservation.

Trace elements

Zinc, iron and copper are very important trace elements in the body at moderate levels unlike hexavalent chromium, which is more toxic than beneficial. The analysis of these in water of wells of the zone of study shows the presence of copper and zinc (0.22± 0.04 mg/L for copper and 0.15 ± 0.05 mg/L for zinc). On the other hand, chromium hexavalent and metallic iron were detected at varying concentrations (0.14 ± 0.05 mg/L and 0.28 ± 0.15 mg/L, respectively). The absence of industrial activity such as metallurgy could justify these low contents of copper and zinc compared to the standards of WHO insofar as the wells are far from the city. However, the origin of chromium VI and metallic iron could only be geological, in particular the predominance of ferruginous soil in the area, household waste discharges or even animal wastes (skins of the animals) (Maldonado, 2009). Metallic pollution from the garbage of artisanal mechanics can be added to these and cotton crops cultivated in the area. Consequently, the population consuming this well water is at risk since chromium VI contents are well above the standards recommended by WHO for drinking.

Conclusion

In this study, we analyzed the physicochemical parameters and some traces elements of the ground water of the chief town of Sinthiou Maléme commune. The waters are averagely mineralized and soft; their pHs is close to neutrality and have more or less acidic character. The photometric analysis of this water intended for human consumption shows that the water table in the study area is polluted. Indeed, the levels of phosphates and hexavalent chromium ions are far from the standard established by WHO. This situation could be explained by the low depth of the wells, their proximity to latrines, the geological nature of the tanks of the aquifers, the intensive use of manure and pesticides and finally the lack of hygiene and management of the garbage surroundings of the wells of the zone. All these realities can compromise the health of the populations consuming these waters due to the severe toxicity of chromium VI. For this purpose, it becomes necessary to develop an efficient method of removing hexavalent chromium from these waters. Furthermore, the study on microbial and toxicological indicators will be envisaged for an overall assessment of the portability of these waters.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Ahoussi EK, Soro N, Kouassi AM, Soro G, Koffi YB, Zade SP (2010). Application of the methods of analyses multivariate statistics being studied of the origin of heavy metals (Cu^{2+}, Mn^{2+}, Zn^{2+} and Pb^{2+}) in water of the ground water of the town of Abidjan. International of Biological Chemical Sciences 4(5):1753-1765.

Aulagnier S, Vittecoq B (2007). Follow-up of the quality of subsoil waters of Martinique, countryside of rain season 2006: results and interpretation. Office report/ratio of geological research and miners Brgm/rp55499-Fr. P 77.

Beaudoin B (2012). Problems ecotoxicologist brought up to date of fluorides in municipal water. 15. https://core.ac.uk/download/pdf/51339825.pdf https://savoirs.usherbrooke.ca/handle/11143/7020

Dimé AKD, Diouf G, Dramé ET, Fall M (2018). Characterization physicochemical of the ground water located in a zone at strong industrial pollution: Case of the commune of Ngoundiane. Journal de la Société Ouest-Africaine de Chimie 46:23-28. http://www.soachim.org/files/volume%2046/4-AKD%20Dim%C3%A9%20et%20al,%20Vol046%20(2018)%2023-28.pdf

Gbohaida V, Agbangnan DCP, Ngossanga MB, Medoatinsa SE, Dovonon LFC, Wotto DV, Avlessi F, Sohounhloue DCK (2016). Etude de la qualité physico-chimique de l'eau de boisson dans deux localités du Bénin: Cotonou et Dassa-Zoumè. International Journal of Biological and Chemical Sciences 10(1):422-434.

Hounsou MB, Agbossou EK, Ahamide B, Akponikpe I (2010). Bacteriological quality of the water in the Ouémé basin: case of total and fecal coliforms in the Okpara, Djougou and Savalou reservoirs in Benin. International of Biological and Chemical Sciences 4(2):377-390.

Kanohin F, Otchoumou E, Yapo OB, Dibi B, Bony AC (2017). Physicochemical and bacteriological characterization of subsoil waters of Bingerville. International of Biological and Chemical Sciences 11(5):2495-2509.

Kanfany G (2009). Effect of organo-mineral fertilization on the growth and yield of the fonio. DEA thesis National Higher School of Agriculture in Thiés / Senegal.

Issa MSS, Mom SAB, Illias A, Ousmane B (2020). Hydrogeochemical characterizations and qualities of water of the ground water high catchment area of Korama, commune of Droum/area of Zinder (Niger/Africa of West). International of Biological and Chemical Sciences 14(5):1862-1877.

Klopp MW (2003). Isotopic study of the nitrogenized pollution of the tablecloth of Alsace between Sierentz and Ottmarsheim. Office report/ratio of geological and mining research Brgm/rp-52331- FR. P 69.

Maldonado DKL (2009). Characterization and origin of metals traces, hydrocarbons aromatic polycyclic and pesticides transported by the atmospheric repercussions and them surface waters in the basins perish-urban separative slopes. Thesis. Central School of Nantes, France.

Maoudombaye T, Ndoutamia G, Ngakou A (2016). Evaluation of the bacteriological quality of water well, drillings and rivers consumed in the oil basin of Doba in Chad. International of Recent Scientific Research 7(6):12236-12243.

Matini L, Sheep JM, Kongo-Mantono Ms (2009). Hydro-chemical evaluation of subsoil waters in urban environment in the South-west of Brazzaville, Congo. Africa Science 5(1):82-98.

Touati M, Benhamza F, Bouhafs F (2018). Impact of agricultural pollution on quality of subsoil waters in the perimeter irrigated Guelma-Bouchegouf (Northern Is Algerian). Review Sciences and Technologies, Synthesis 37:103-112. https://www.ajol.info/index.php/srst/article/view/182105

Republic of Senegal (2007). Ministry for Rural Hydraulics and the Hydrographic Network National, Ministry for Infrastructures and of the Cleansing Area of local Plane Tambacounda of hydraulics and of cleansing - PLHA the rural Community of Sinthiou Maléme.

Rodier J, Legube B, Merlet N (2009). Analysis of water, Dunod, Paris, France 1579 p.

Sandao I, Abdoubabaye Ms, Ousmane B, Michelot JL (2018). Contributions of the natural isotopes of water with the characterization of the mechanisms of refill of the aquifers of the basin of Korama, Area of Zinder, Niger. International of Biological and Chemical Sciences 12(4):1931-1954.

Ouandaogo-Yameogo S (2008). Groundwater resources in the urban center of Ouagadougou in Burkina Faso, quality and vulnerability. Thesis. University of Avignon and the countries of Vaucluse France. https://www.theses.fr/2008AVIG0040

World Health Organization (WHO) (2004). Directives of qualities for the drink water (3rd edition). 1.

Yapo OB, Mambo V, Seka A, Ohou MJA, Konan F, Gouzile V, Tidou AS, kouame KV, Houenou P (2010). Evaluation of the quality of water of well with use domesticates in the districts disadvantaged of four communes of Abidjan (Côte. d'Ivoire): Koumassi, Marcory, Port-Bouet and Treichville. International of Biological and Chemical Sciences 4(2):289-307.