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Research Article
Evaluation of the Physico-chemical Quality of Drinking Water in Two Districts of Lomé (Togo)

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Abstract

Background and Objective: Consumption of water contaminated by the heavy metals can lead to many biological disorders, cancers or even death. The aim of this study was to evaluate the physicochemical quality of well water and boreholes at 2 sites in Lomé (Togo). **Materials and Methods:** Analysis was made by atomic absorption spectrophotometer (AAS) for metallic trace elements and the molecular absorption spectrophotometer for nitrates. **Results:** Well and borehole water from the Agoè Sorad site, close to a large garbage dump, are acid. They were polluted with nitrates with concentrations exceeding the WHO standard. The well and borehole waters of the Bè Aveto site, whose soil was sandy than the previous site, was alkaline and have nitrate pollution with concentrations exceeding the WHO standard. The site was subject to metallic pollution with As, Hg, Pb, Cd and Cu with concentrations above their respective standards with the exception of Cu. **Conclusion:** This study shows that the 2 sites (Agoè Sorad de Bè Aveto) are polluted with nitrates. Regarding the metallic trace elements studied, the waters of the Agoè Sorad site are safe for consumption. This study also shows that there are potential health risks related to exposure to As, Hg and Pb through the consumption of well water and boreholes at the Bè Aveto site. At the end of this study, the results have shown that the site of Bè Aveto is more polluted than the site of Agoè Sorad.

Key words: Well waters, boreholes, conductivity, nitrates, heavy metals

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The demographic growth in developing countries and their difficult economic conditions are leading to anarchic urbanization that is difficult to control[1]. This population surge occurs in peri-urban areas and leads to an increase in the production of waste and household waste[2]. The resulting pollution of anthropogenic activities represents a worrying threat to human beings and the environment. Industrial waste water and the intensive use of fertilizers, pesticides, sanitary, agricultural and pharmaceutical products are the major causes of contamination of natural waters[3,4].

The World Health Organization (WHO)[4] estimated that 9% of the world's population did not have access to safe drinking water and 32% did not have access to improved sanitation services. Sub-Saharan Africa and Oceania are the most affected parts of the world[4].

The city of Lomé, for its part, is characterized by a sanitation rate of 31% and a drinking water supply rate of 58%, so it has a deficit in drinking water[5,6]. In urban areas and especially in outlying areas, part of the population turns to well and bore water without prior treatment for their food[7].

Continuous and permanent discharge of large quantities of waste into the natural environment favors the dispersion and diffusion of metallic trace elements (heavy metals) and nitrates. Those are cumulative toxins that cause huge health damage[8,9]. Several studies have reported groundwater pollution in 2012 in Senegal, in 2013 in Algeria and Côte d'Ivoire, in 2015 in Nigeria and Zimbabwe and in 2016 in France[3,10,11]. As a result, the consumption of water contaminated by the heavy metals can lead to an accumulation in the organs of human thus causing their dysfunction, the stopping of many biological reactions, cancers or even death.

Studies conducted in 2007 in China and Bangladesh and in 2017 in Morocco have shown that the presence of high levels of arsenic and lead in drinking water is associated with a decrease in cognitive performance[12-14]. A study conducted in Togo in 2012, had only determined the heavy metal composition of waste from the Agoe Sorad site[15].

Apart from heavy metals, nitrates (NO_3^-) are also inorganic pollutants, whose mobility and stability can make them very dangerous in natural waters[16]. They contribute to eutrophication (excess nutrients in the water leading to a proliferation of vegetation, oxygen depletion and an imbalance of the ecosystem) of rivers. NO_3^- may also be the cause of a number of serious human health problems such as methemoglobinemia[17] and the potential formation of carcinogenic nitrosamines[18,19]. Considering the danger posed by heavy metals and NO_3^-, the density of populations and the presence of garbage dumps in the areas of Agoe Sorad and Be Aveto, the aim of this study was to evaluate the physicochemical quality of the well and boreholes of Agoe Sorad and Be Aveto.

MATERIAL AND METHODS

Framework of study: The framework of study was the prefecture of the Gulf, more precisely the districts "Agoe-Sorad" and "Be Aveto". In the continuation of the document expressions: site of Agoe Sorad and site of Be Aveto was used. The site of Agoe Sorad is located in the vicinity of the big dump of Agoè and extends about 800 m. The site of Be Aveto is located in Be, next to the sacred forest. It stretches for about 600 m. The site of Be Aveto rests on a sandy soil.

Sampling equipment: The material used for the collection consists of cooler, plastic bottles of 100 and 500 mL, cooler, marker and scotch paper.

Equipment: The equipment and laboratory consumables used were an atomic absorption spectrophotometer (SAA) (SOLAAR S2 THERO FISCHER brand), a molecular absorption spectrophotometer (HACH DR 3800), a Knick portamess brand conductivity meter and a pH meter (Crison type).

Reagents: The reagents used for the determination of the various parameters are pure nitric acid (67.56%) (Ref 10604170 JEULIN 27019 Evreux Cedex France).

Methods

Sampling: The sampling of water took place in November, 2017. The analysis was carried out on the groundwater of wells and boreholes in the Agoe-Sorad and Be Aveto districts. 16 samples were taken from eight wells and eight boreholes at the Agoe Sorad site and ten samples from 6 wells and 4 boreholes at the Be Aveto site. This difference in the number of samples was due to the size of the study sites (Agoe Sorad larger than Be Aveto). These samples had been the subject of a physico-chemical characterization and the analysis of some heavy metals in the "GTVD" laboratory of the University of Lomé. The samples were taken in plastic bottles of volume 100 mL for the heavy metals and those of 500 mL for the NO_3^-. The flasks had been previously washed and rinsed with tap water and distilled water. In the field, the flasks had been rinsed with water from the site before filling. The samples contained in the 100 mL flasks had been acidified with a few drops of nitric acid. The vials were filled in a way that there was no air above the sample to prevent oxidation of the heavy metals. Measurement of physical parameters, indicator of water quality such as pH and conductivity was also performed.

Determination of metallic trace elements: The metal trace elements (Pb, Cd, Cu, Hg, As) were measured with the SAA atomic absorption spectrophotometer (SOLAAR S2 brand THERO FISCHER), the only method currently available at the University of Lomé for this assay. The concentrations are expressed in mg L^{-1} for Pb, Cd and Cu and in µg L^{-1} for Hg and As. Analysis were made by the molecular absorption spectrophotometer for nitrates.

Statistical analysis: Results were expressed in mean±standard error on the mean (SEM). Statistical analysis was performed by analysis of variance (ANOVA) with Tukey test to evaluate the difference between 2 groups. Values of $p<0.05$ were considered significant. The Instat statistical package (GraphPad Prism 6.02) was used to carry out all statistical analysis.

RESULTS

Physico-chemical parameters of the Agoe Sorad site: The results of the physico-chemical analysis of the main well water parameters are presented in Table 1. The tests results have shown that all the waters of this site had an acidic pH. The conductivity was higher than the WHO standard of more than 4 times. Table 2 presents the variations of the physico-chemical parameters in the drilling waters of Agoe Sorad. The results showed that the Agoe Sorad site had high conductivities, i.e., an average of 4538.4±712.9 in well water and 2546±444.2 in borehole water. Mean values of NO_3^- in wells (134.79±41.48) and boreholes (100.21±41.48) were above the WHO standard.

Table 3 shows the distribution of heavy metals at different distances from the garbage dump. The contents of the different heavy metals do not vary according to the distance between the discharges of the sampling points.

Physico-chemical parameters of the Be Aveto site: Table 4 and 5 show the variation of pH, conductivity, NO_3^- and heavy metals in the well and borehole waters of the Be Aveto site. Analysis of the waters of the Be Aveto site showed that the average pH value is 7.08±0.08 in well water and 6.90±0.1 in borehole water. NO_3^- concentrations in well water (94.8±20.4 mg L^{-1}) and boreholes (101.5±36.5 mg L^{-1}) were above the WHO standard.

Pb is present in all samples with average concentrations in well water (0.03±0.006) and boreholes (0.08±0.01) above the WHO standard. Cadmium is 10 times higher than standard in Be Aveto well waters. Regarding the drilling water in the Be Aveto district, the same increase was observed except that the cadmium content is normal. The comparison of the 2 sites shows that the Be Aveto site is older than that of Agoè Sorad (Table 6).

DISCUSSION

The results of the physico-chemical analysis presented in this study showed that all the waters of the site had an acidic pH. These results showed that 87.5% of the wells were above the WHO standard. This acidity is characteristic of coastal groundwater whose pH is controlled by hydrogeological factors. Acidic water distributed through a pipeline system (case of drilling) may indirectly induce a threat to the health of the misinformed or reckless consumer[20]. The results (87.5%) are higher than those obtained during the study carried out by Tanouayi *et al.*[7] In Agoe zongo, 23.07% of the wells was acid and had non-standard pH.

Conductivity is the ability of water to conduct electrical current, it determines the overall composition of the mineral salts present in water. Fresh water will have a low conductivity

Table 1: Variation of physicochemical parameters in the well waters of Agoe Sorad

Parameters	Mean (n = 8)	Minimum	Maximum	WHO standard
pH	6.28±0.13	5.53	6.89	6.5-9.5
CE (µS cm^{-1})	4538.38±712.89	1927.00	8310.00	1000
As (µg L^{-1})	1.08±0.07	0.83	1.32	10
Hg (µg L^{-1})	1.80±0.10	1.46	2.34	6
Cu (mg L^{-1})	0.01±0.002	0.006	0.025	2
Pb (mg L^{-1})	ND	ND	ND	0.01
Cd (mg L^{-1})	ND	ND	ND	0.03
NO_3^- (mg L^{-1})	134.79±41.48	5.33	365	50

Each value represents the Mean±ESM, n: Number of wells, ND: Not determined

Table 2: Variation of the physicochemical parameters in the drilling waters of Agoe Sorad

Parameters	Mean (n=8)	Minimum	Maximum	WHO standard
pH	6.78±0.07	6.52	6.99	6.5-9.5
CE (µS cm^{-1})	2546±444.21	768	4800	1000
As (µg L^{-1})	0.75±0.16	0.2	1.59	10
Hg (µg L^{-1})	2±0.16	1.44	2.77	6
Cu (mg L^{-1})	0.02±0.002	0.01	0.03	2
Pb (mg L^{-1})	ND	0.05	0.05	0.01
Cd (mg L^{-1})	ND	ND	ND	0.003
NO_3^- (mg L^{-1})	100.21±41.48	8	345	50

Each value represents the Mean±ESM, n: Number of wells, ND: Not determined

Table 3: Distribution of heavy metals in the waters in relation to the distance between the sampling points at the Agoe Sorad

Distance	n	Cu	As	Hg	Cd	Pb
0-200 m	1	0.02	0.74	1.64	ND	ND
200-400 m	8	0.02±0.01	1±0.12	1.99±0.11	ND	ND
400-600 m	7	0.02±0.01	0.84±0.14	1.84±0.18	ND	ND

Each value represents the Mean±ESM, n: Number of wells, ND: Not determined

Table 4: Variation of physicochemical parameters in Be Aveto well waters

Parameters	Mean (n = 6)	Minimum	Maximum	WHO standard
pH	7.08±0.08	6.83	7.4	6.5-9.5
CE (µS cm^{-1})	1743.17±246.60	1168	2750	1000
As (µg L^{-1})	6.98±1.33	3.47	11.1	10
Hg (µg L^{-1})	3.84±0.52	2.57	5.07	6
Cu (mg L^{-1})	0.02±0.001	0.02	0.028	2
Pb (mg L^{-1})	0.03±0.005	0.01	0.05	0.01
Cd (mg L^{-1})	0.03±0.006	0.002	0.004	0.003
NO_3^- (mg L^{-1})	94.78±20.36	22.7	153	50

Each value represents the Mean±ESM, n: Number of wells, ND: Not determined

Table 5: Variation of the physicochemical parameters in the drilling waters of the Be Aveto site

Parameters	Mean (n = 4)	Minimum	Maximum	WHO standard
pH	6.90±0.10	6.63	7.08	6.5-9.5
CE (µS cm^{-1})	1740.5±96.57	1554	2010	1000
As (µg L^{-1})	3.82±0.10	2.41	6.2	10
Hg (µg L^{-1})	2.30±0.36	1.56	3.23	6
Cu (mg L^{-1})	0.04±0.01	0.03	0.05	2
Pb (mg L^{-1})	0.08±0.02	0.07	0.10	0.01
Cd (mg L^{-1})	ND	0.002	0.002	0.003
NO_3^- (mg L^{-1})	101.46±36.47	18.7	193	50

Each value represents the Mean±ESM, n: Number of wells, ND: Not determined

Table 6: Comparison of the 2 sites (Agoe Sorad and Be Aveto)

Parameters	Agoe sorad site	Be aveto site
Age	Under 20 years and closed	More than 20 years old and active
Soils	Sands and clays	Sands
pH	Acid	Alkaline
Conductivity	High	High
NO_3^- (mg L^{-1})	>50 mg L^{-1}	>50 mg L^{-1}
Heavy metals in well water	As. Hg. Cu	As. Hg. Cu. Pb*. Cd*
Heavy metals in drilling water	As. Hg. Cu	As. Hg. Cu. Pb*

*Heavy metals have concentrations exceeding the WHO standard

and hard water will have a high conductivity. This study results showed that the Agoe Sorad site had high conductivities, is an average of 4538.4±712.9 in well water and 2546±444.2 in borehole water. High conductivities could be explained by the depth of the levels collected and the geological nature of the soil formations[21].

Chemical characterization showed that average NO_3^- values in wells (134.79±41.48) and boreholes (100.21±40.18) were above the WHO standard. These results are superior to those of Maoudombaye *et al.*[22] in Chad who found NO_3^- values 24.97±17.61 in well water and 49.17±6.86 in borehole water. In addition, 62.5% of the wells and boreholes were outside the

WHO standard (50 mg L^{-1}). These results can be explained by the proximity of the study site to the landfill, the discharge of wastewater and the proximity of septic tanks. The results (62.5%) are higher than those obtained by El Haissoufi *et al*.[23]. in Fez, Morocco, the results of which corresponded to the WHO standard.

With regard to the heavy metals, results showed that the Pb and the Cd were below the detection threshold, which therefore did not exist despite the presence of the landfill, road traffic and car garages in the area. This can be explained by the detection capabilities of the spectrophotometer. These results (absence of Cd and Pb) go in the same way as those obtained by Aderemi *et al*.[24] and Idlahcen *et al*.[25], who respectively noted in Nigeria an absence of Pb and Cd and in Morocco lack of Cd in groundwater but present in leachates. This absence was justified by the geology of the environment which was made of clay soils. Mercury poisoning primarily affects the central nervous system and the kidney. This study results are lower than those of Degbey *et al*.[26] in Benin who found that 40% of the wells were non-standard of WHO.

Regarding Cu, considered as a trace element by WHO[4], it is present in all samples but remains below the WHO standard. This study results (0.02±0.001) are consistent with those of Majolagbe *et al*.[10], in Nigeria.

Analysis of the waters of the Be Aveto site showed that the average pH value is 7.08±0.08 in well water and 6.90±0.1 in borehole water. The pH is neutral in well waters and acidic in boreholes. They fall within the range of potability of WHO (6.5-9.5). These results (7.08) are lower than those of Amadou *et al*.[27] in Niger and Ling and Zhang[28], in China , who found a pH respectively at 7.23 and 7.53 in the waters of well. In addition, these results are superior to those of Maoudombaye *et al*.[22] in Chad who found a pH at 5.47±0.54 in well water and 5.75±0.54 in borehole water.

Chemical characterization showed high concentrations of NO_3^- in well water (94.8±20.4 mg L^{-1}) and boreholes (101.5±36.5 mg L^{-1}). These results are superior to those of Maoudombaye *et al*.[22] in Chad and Lagnika *et al*.[29] in Benin, who found NO_3^- concentrations about 24, 97±17.61 mg L^{-1} (well water) and 49.17±6.86 mg L^{-1} (drilling water) and 45.30±40.80 mg L^{-1} (well water), respectively. In addition, the results show that 83% of the wells and 75% of the boreholes were above the WHO safety standard. These results can be explained by the proximity of the Be Aveto site to the be landfill and the leaching of organic waste that it entails. They can also be explained by the presence of latrines near water points. These results (83%) are higher than those obtained by Al-Qawati *et al*.[30] in Morocco who found that 68% of the wells were outside the WHO standard.

Pb is present in all samples with mean concentrations in well water (0.03±0.006) and well drilling (0.08±0.01) above the WHO standard. The presence of Pb would be due to the atmospheric fallout of pollutants from motor vehicles, batteries and batteries that filled the discharge of Be Aveto. Our results (0.03±0.006) are higher than those of Abd El-Salam and Ismail[31] and Majolagbe *et al*.[10], who obtained respectively 0.005±0.001 mg L^{-1} in Egypt and 0.001 in Nigeria.

In addition, the results of this study showed that As and Hg were present in Be Aveto groundwater and mean concentrations were below the WHO standard. The presence of As and Hg can be explained by the influence of leachate from the Be landfill, the road traffic and the proximity of the Be Aveto site to the autonomous port of Lomé, which is an industrial zone. These results are different from those obtained by Han *et al*.[32] in China who found an average value of Hg higher than the WHO safety value.

In addition, this study results showed that Cu was present in groundwater and corresponded to the WHO standard (Table 6). These results (0.024±0.001) are in agreement with those of Majolagbe *et al*.[33] in Nigeria, Gul *et al*.[34] in Pakistan, Bakouan *et al*.[35], who found Cu contents lower than the WHO standard (2 mg L^{-1}). With regard to Cd, the results showed that it was present in 2 wells and in a borehole with grades exceeding the WHO standard. These results can be explained by the nature of the soil (sands) of the study site. These results correspond with those obtained by Lagnika *et al*.[29]. The analysis of the physical parameters showed that the Agoe Sorad site had an acidic pH, unlike the Be Aveto site, which had an alkaline pH. These results can be explained by the age of the Be Aveto landfill where organic matter has been more degraded. In view of the results obtained, it can be said that the site of Be Aveto, older and sandier than that of Agoè Sorad, is the most polluted.

CONCLUSION

This study shows that the 2 sites (Agoè Sorad de Bè Aveto) are polluted with nitrates. Bè Aveto is more polluted than the site of Agoè Sorad. There are potential health risks related to exposure to As, Hg and Pb through the consumption of well water and boreholes at the Bè Aveto site. This study discovers that the consumption of well and drilling water of the 2 sites (Agoè Sorad de Bè Aveto) can be at the origin of serious health problems in our country. The result should help our authorities to take steps in order to prevent the risk of Pb, Hg and As intoxication.

SIGNIFICANT STATEMENT

This study discovers that the consumption of well and drilling water can be at the origin of serious health problems in our country. The result should help our authorities to take steps in order to prevent the risk of Pb, Hg and As intoxication. Our results have shown that the site of Bè Aveto is more polluted than the site of Agoè Sorad.

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