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Physico-chemical quality of the Okpara River waters and well waters in the commune of Parakou in northeastern Bénin

Fadeby Modeste Gouissi*[1,2], Nonvignon Martial Fassinou[2], Clemence Claire Aguessy[2], Dagbedji Damien Toffa[1], Gbetoho Kemal Bessan[2], Roch Christian Johnson[1], Pierre Midogbo Gnonhossou[2]

[1]*Laboratory of Hygiene, Sanitary, Ecotoxicology and Environmental Health (HECOTES), Interfaculty Centre of Training and Research in Environment for Sustainable Development (CIFRED), University of Abomey-Calavi (UAC), Jericho, Cotonou, Bénin*

[2]*Faculty of Agronomy (FA), University of Parakou (UP), Parakou, Bénin*

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Abstract

Water is a precious and essential natural resource for multiple uses. Its use of food or hygiene purposes requires excellent physico-chemical quality. Our study aims to compare the water quality of the Opkara River with Parakou well waters. The water samples collected from ten sampling points, 5 points for well waters, and 5 for the Opkara River waters were analyzed by measuring the following physico-chemical parameters: Temperature, pH, electrical conductivity, total dissolved solids, turbidity, oxygen, nitrate, nitrite, phosphate, calcium, magnesium, chemical oxygen demand (COD), iron, and chloride. The results showed that the majority of the well waters that we studied were suitable for human consumption. Apart from the temperature, turbidity and iron values that exceed the drinking water quality of Bénin in 2001 and WHO in 2011, all other parameters were found to be within the standard limits. The water was then qualified as polluted through its physico-chemical constituents evaluated which were very low or none compared to the standard norms suggested by the WHO in 2011 and Bénin in 2001 for drinking water. As for the river, these waters were turbid and less potable than the well waters from which they presented risks for consumption.

***Corresponding Author:** Fadéby Modeste Gouissi ✉ gouissi@yahoo.fr

Introduction

Freshwater ecosystems are natural compartments needed for the continuity of life (Simpi, 2011). They are essential for various activities such as supplying municipalities with drinking water, industry, agriculture and recreation. Unfortunately, they are among the ecosystems most seriously threatened by the impact of human activities during this last century (Cox *et al.,* 2002; Dudgeon *et al.,* 2006). Indeed, population growth, accompanied by rapid urbanization causes many disturbances to natural environments (Mc Kinney, 2002). Water intended for human consumption is drinkable by exempting from chemical and biological elements and likely to be a long-term healthy life of individuals (John and Donald, 2010). According to the WHO (2005), every year 1.8 million people, 90% of whom are children under five, most of whom live in developing countries, die of diarrheal diseases (including cholera). 88% of diarrheal diseases are attributable to poor water quality, poor sanitation, and poor hygiene.

In Bénin, approximately 13 billion cubic meters water per year found to be estimated the water potential of rivers except for the waters of the Niger River. The current use of these surface waters is very insignificant and only concerns the supply of drinking water to a few cities, the watering of livestock and the irrigation of about 9000 hectares of various crops. However, projections of irrigation development in Bénin predict an increase in water demand for the next few years.

About groundwater, it is currently difficult to quantify the water reserves in Bénin's aquifers due to the availability of limited data. However, their recharge capacity estimated at 1.9 billion cubic meters on average per year and mainly used for drinking water in cities and the countryside. Annual withdrawals are of the order of 0.03 billion cubic meters per year. The above data represents barely 2% of the yearly aquifer recharge. But this abundance of groundwater is only relative because, in the basement regions (80% of the national territory in the Center and the North), the groundwater potential will not be sufficient to cover the long-term needs. It will then be necessary to resort to surface water to supplement this relative deficit. Unfortunately, current conditions for the exploitation and management of natural resources, in general, pose severe threats to the protection and preservation of water resources and consequently to the survival of future generations. In general, the development of microbial communities in both surface and groundwater is related to meteorological factors and all the physicochemical and biological characteristics of the biotope. Many parameters quantify the physical or chemical elements (temperature, turbidity, pH, electrical conductivity, dissolved oxygen, nitrite, nitrate, phosphate, COD, chloride, etc.). Several indicators of the pollutant load resulted from human activities. The objective of our research is to make a comparative study of the physicochemical quality of the waters of the Okpara River and some wells of the commune of Parakou.

Materials and Methods

Location of the Okpara River

The Okpara river located between 8°13' and 10°03' N latitude and between 2°31' and 3°25' E longitude covers the departments of Collines and Borgou and is one of the two main tributaries of the Ouémé River in Bénin. (INSAE, 2013) (Fig. 1).

Sampling points

To assess the quality of the waters of the Okpara River and the quality of the well waters, we have chosen the communes of Tchaourou and Parakou. We selected 05 sampling points in the commune of Tchaourou, whose positions are more exploited by the population through agricultural activities, animal grazing, washing, laundry, and drinking. According to the wells, the commune of Parakou was chosen, through 05 wells, catching those randomly taken samples from the various dwellings, some of which are near the lavatories and some without a lid (Fig 2).

Water sampling

The samples were taken in plastic sterilized vials, 1.5 liters of water at each sampling point during October 18, 2018, and refilled immediately after sampling. The physical parameters were measured directly on the different sampling points. Samples were stored under refrigerated conditions (4°C) and taken to the laboratory for a maximum time of 5 hours for the various series of analysis and analyzed within 24 hours. (Fig 2) shows the Okpara River sampling points in yellow color and the well sampling points in red color.

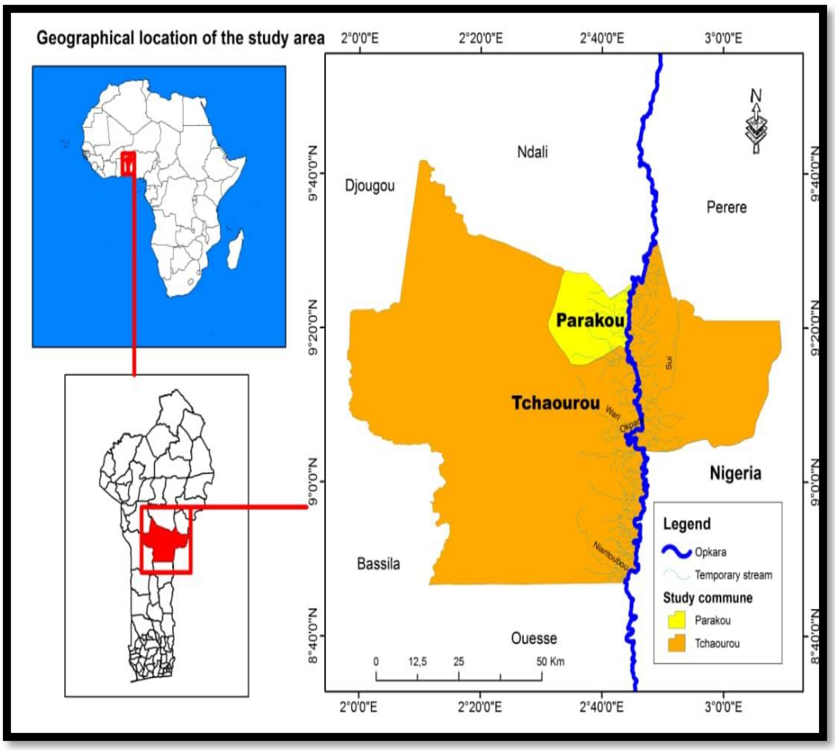

Fig. 1. Map of the study area.

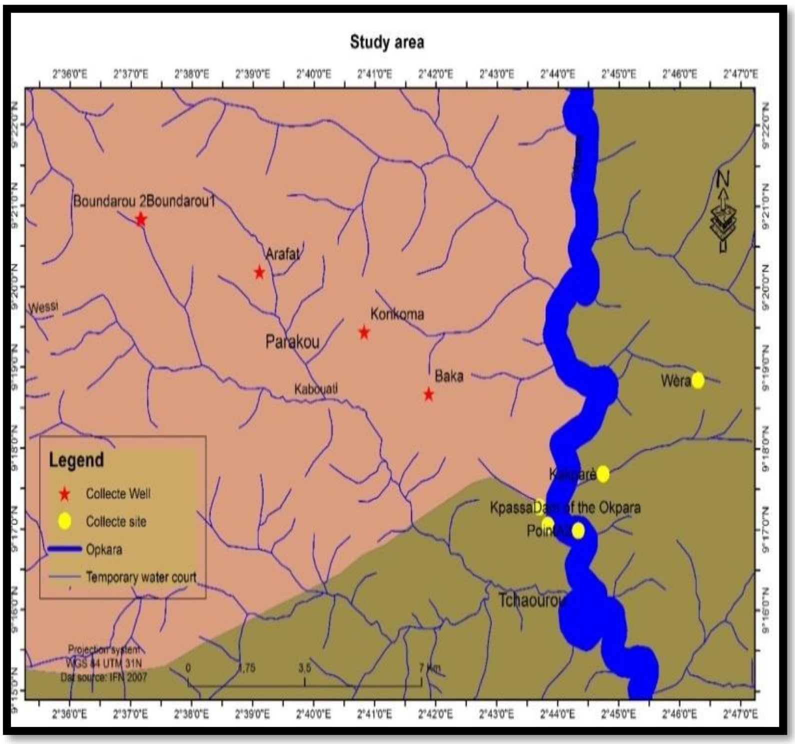

Fig. 2. Map of sampling points.

Physico-chemical analyzes

During the execution of work, we followed the modus operandi adopted by Rodier *et al.,* (2009) and the recommendations of the World Health Organization and Bénin. The temperature is recorded directly at the sampling points using a pH meter. The pH is determined using a pH meter, which allows the measurement of a potential difference existing between a glass electrode and a reference electrode immersed in the same solution. The electrical conductivity expressed in micro-siemens per centimeter (µs/cm) is measured using a conductivity meter.

Total dissolved solids expressed in milligrams per liter (mg/L) are measured using a conductivity meter. Dissolved oxygen expressed in milligrams per liter (mg/L) is measured with an oximeter. The turbidity, which is the reduction of the transparency of the liquid due to the presence of undissolved material, is determined using a turbidimeter. Nitrate, nitrite, phosphate, calcium, magnesium, chemical oxygen demand, iron, and chloride are expressed in milligrams per liter (mg/L) and measured with a spectrophotometer DR 6000.

The histograms were made from the Excel spreadsheet to show the comparative variation of each of the evaluated parameters. Then, the correlation circle recognized with the software R version 3.5.0 to establish the correlations between the variables with the parameters assessed by analyses in the tables.

Results

To compare the physico-chemical quality of the water intended for human consumption from the Okpara River waters in Tchaourou and the well waters in the commune of Parakou, we performed global statistical analyses for the ten (10) water samples collected. By selecting various parameters, the program determined the averages. In essence, we compared our results with the standard norm by WHO and Bénin. Table 1 presents the variation of the chemical concentration in the water samples.

Table 1. Variation of the chemical concentration in water samples.

Parameters	Obtained values			Bénin standards (2001)	WHO standards (2011)
	Units	Mean values of Okpara River	Mean values of the wells of Parakou		
Température	^{0}C	26.8	28.4	25	25
pH	Unité pH	7.14	6.5	6.5-8.5	6.5- 8.5
Conductivity	µS/cm	40.72	584	2000	< 1500
TDS	mg/L	18.31	283	2000	< 600
Dissolved Oxygen	mg/L	3.01	3.98	≥ 5	$5 \leq O_2 \leq 8$
Turbidity	FAU	73.8	5	5.0	< 1
Nitrate	mg/L	0.58	13.8	45	<50
Nitrite	mg/L	0.2	0.6	3.2	< 0.1
Phosphate	mg/L	0.05	0.01	5	
Calcium	mg/L	0.55	0.22	100	200
Magnesium	mg/L	2.16	2.10	50	150
COD	mg/L	7.55	0	26.02	30
Iron	mg/L	2.37	0.38	0.3	PVG
Chloride	mg/L	4.74	13.94	250	≤ 250

Temperature

The values of the above parameter are ranging from 25.5°C (Kpassa) in the Okpara River to 28.8°C (Baka and Banapassa 1) at the wells of the commune of Parakou. Hence, the temperature at the wells in Parakou is moderately high (28.4°C) unlike that of the Okpara River (26.5°C). The instructions recommended by the WHO and Benin standard norms was that the optimum temperature of drinking water was 25°C for both the cases. We found that the temperature of all samples taken exceeds 25°C. Therefore, a temperature exceeding 25°C promotes the growth and development of microorganisms. Fig. 3 shows the spatial variation of the temperature.

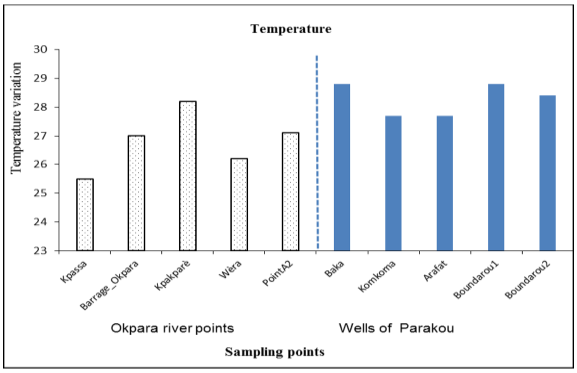

Fig. 3. Spatial variation of temperature values.

pH

The range of pH values remained from 6.6 (Kpassa) to 7.8 (Point A2) for the waters sampled in the Okpara River. While the hydrogen potential at the wells in the commune of Parakou is moderately lower (6.5), unlike that of the Okpara River (7.14). The pH of the Okpara River waters and the well waters in the commune of Parakou are relatively neutral. Thus, the quality of this water matches adequately with the standard norm of the WHO (6.5 to 8.5) and Bénin (6.5 to 8.5) for drinking water. Hence, the water quality of the Okpara River and that of the wells in the commune of Parakou is acceptable. Fig. 4 shows the spatial variation of the hydrogen potential.

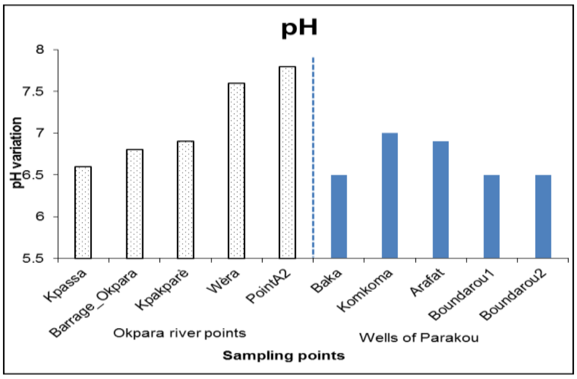

Fig. 4. Spatial variation of hydrogen potential values.

Electrical conductivity

The values of electrical conductivity range from 33µs/cm at point A2 in the Okpara River to 777µs/cm at Boundarou 1 at the wells in the commune of Parakou. But the electrical conductivity at the wells in Parakou is moderately high (584µs/cm), unlike that of the Okpara River (40.72µs/cm). Referring to WHO standards (<1500µs/cm) and Bénin standards (2000µs/cm), we found that these values are much less than the average. The waters of the Okpara River contain fewer ions than those of the wells in the commune of Parakou. Therefore the Okpara River water and the well waters in the commune of Parakou do not pose a risk and eventually accepted, and very low in electrical conductivity. Fig. 5 shows the spatial variation of electrical conductivity.

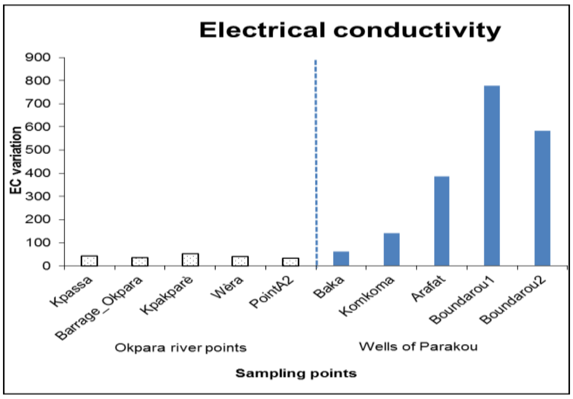

Fig. 5. Spatial variation of electrical conductivity values.

Total Dissolved Solids

The values of total dissolved solids ranged from 13.3mg/L at Okpara Dam to 379mg/L at Boundarou 1 well waters in the commune of Parakou. Consequently, the total dissolved solids at the well waters in the commune of Parakou are moderately high (283mg/L), unlike that of the Okpara River (18.31mg/L). Based on WHO standards (<600mg/L) and Bénin standards (2000mg/L) for drinking water, we found that these values are lower than required. Subsequently, the Okpara River waters and well waters in the commune of Parakou are acceptable and poorly represented as total dissolved solids. Fig. 6 shows the spatial variation of total dissolved solids.

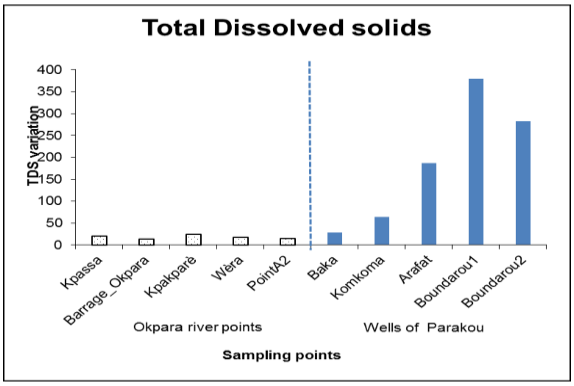

Fig. 6. Spatial variation of total dissolved solids values.

Dissolved oxygen

Dissolved oxygen values range from 1.33mg/L (Kpakparè) to 5,16mg/L (Kika 2) which are respectively the minimum and maximum values in the Okpara River. However, the dissolved oxygen of the well waters in the commune of Parakou is moderately high (3.98mg/L), unlike that of the waters of the Okpara River (3.01mg/L). It is one of the most sensitive parameters of pollution. The dissolved oxygen content defined for the WHO (5 O O2 ≤8) and Benin (≥ 5mg/L) standards for drinking water. We found that almost all the values of the sampling points are below the standards defined by Bénin and WHO except Point A2 (5.16mg/L). Hence, the waters of the Okpara River and the well waters in the commune of Parakou are not as acceptable drinking water because it dissolved oxygen. Fig. 7 shows the spatial variation of dissolved oxygen.

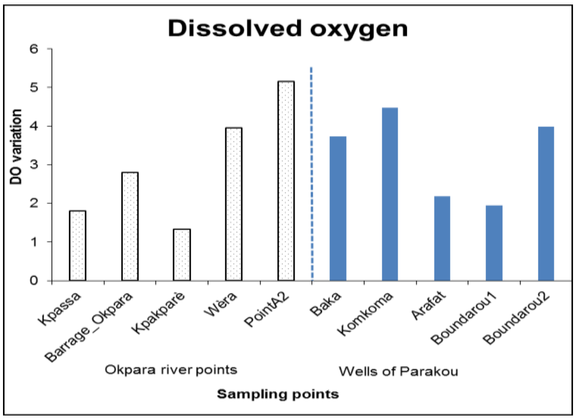

Fig. 7. Spatial variation of dissolved oxygen values.

Turbidity

Turbidity parameter varies from 1 FTU at Arafat and Boundarou well waters in the commune of Parakou to 199 FTU at Wèra. The turbidity values of the well waters in the commune of Parakou are moderately lower (5 FTU), unlike those cases of the Okpara River (73,8 FTU), as characterized by suspended materials according to standards referred for WHO (<1 FTU) and Bénin (5 FTU). We note that the values obtained for the Okpara River points are much higher compared with those of the wells in the commune of Parakou and does not respect the WHO and Bénin standards for drinking water excep a few well waters. Fig. 8 depicts the spatial variation of turbidity values.

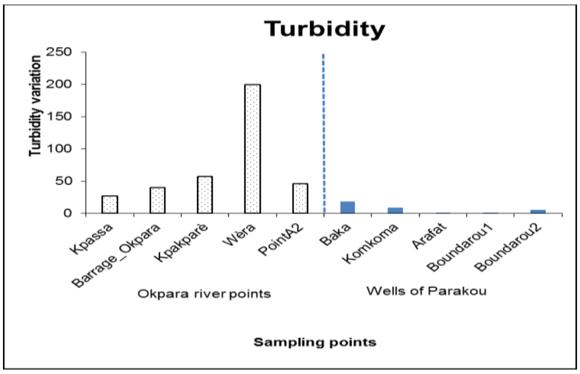

Fig. 8. Spatial variation of turbidity values.

Nitrate

Nitrate values range from 0mg/L for waters at Kpakparè and Wèra of the Okpara River to 13.8mg/L for well waters at Boundarou 2 in Parakou. So, the nitrate values of the well waters in the commune of Parakou are moderately high (13.8mg/L), unlike that of the waters of the Okpara River (0.58mg/L). These values were found to be within those defined by WHO (<50mg/L) and Bénin (45mg/L) for drinking water. Hence, the Okpara River waters and well waters in the commune of Parakou are acceptable for drinking water, and this low nitrate values of the Okpara River can be explained by the study season, resulting in a high level of leaching. Fig. 9 shows the spatial variation of the nitrate values.

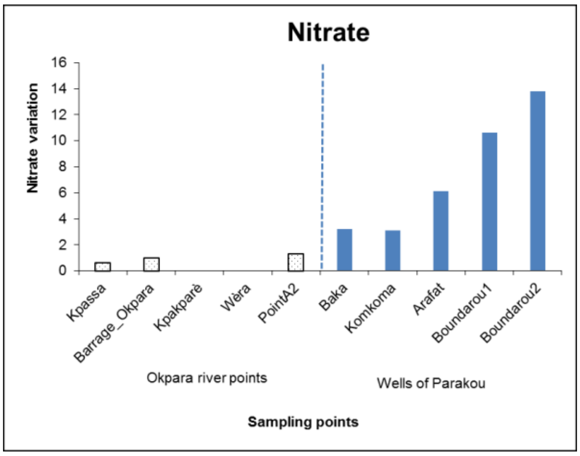

Fig. 9. Spatial variation of nitrate values.

Nitrite

Nitrite values are 0mg/L for all sampling points except point A2 (1mg/L) at the Okpara River and Baka (3mg/L) for well waters in the commune of Parakou.

So, the nitrite values of well waters in the commune of Parakou is moderately high (0.6mg/L), unlike that of the waters of the Okpara River (0.2mg/L). The value obtained was influenced by rainy season. We found that the nitrite is in low concentration in the waters of the Okpara River and the well waters in the commune of Parakou were not exceeding Bénin standards (3.2mg/L) but contrary to WHO standards (<0.1mg/L). Hence, the water quality of the Okpara River and that of the wells in the commune of Parakou is also acceptable with nitrite. Fig. 10 presents the spatial variation of the nitrite values.

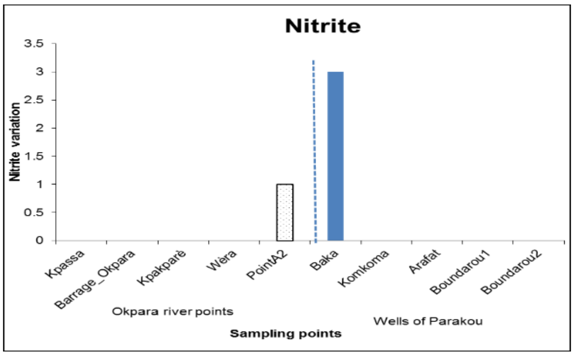

Fig. 10. Spatial variation of nitrite values.

Phosphate

Phosphate values range from 0mg/L in Baka for well waters in the commune of Parakou to 0.149mg/L in Kpassa at the Okpara River. Here, the phosphate values of well waters in the commune of Parakou are moderately lower (0.01mg/L), unlike that of the waters of the Okpara River (0.05mg/L). These values respect the standards required by the WHO (≤ 0.5mg/L) and Bénin (5mg/L) for drinking water. The content is considered normal and acceptable in phosphate. Fig. 11 shows the spatial variation of the phosphate values.

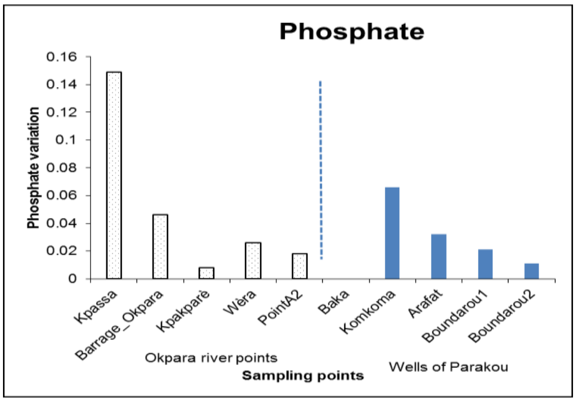

Fig. 11. Spatial variation of phosphate values.

Calcium

The calcium values range from 0mg/L at the Okpara Dam and Boundarou 1 for the Okpara River waters and well waters in the commune of Parakou to 1.24mg/L at Wèra for the Okpara River waters. The calcium at the well waters in the commune of Parakou is moderately lower (0.22mg/L), unlike that of the waters of the Okpara River (0.55mg/L). For standards defined by WHO (200mg/L) and Bénin (100mg/L) for drinking water, the values obtained are shallow. Therefore, the water is acceptable in calcium, which is considered normal for health. Fig. 12 shows the spatial variation of the calcium values.

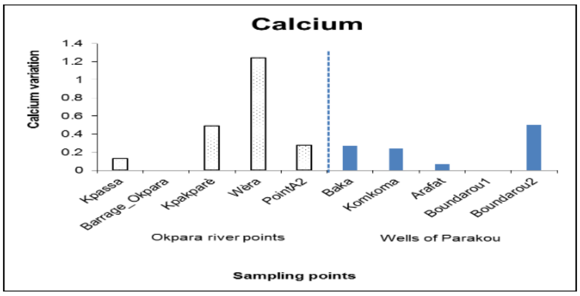

Fig. 12. Spatial variation of Calcium values.

Magnesium

The values of this parameter range from 1.74mg/L at Kpakparè for the Okpara River waters to 2.49mg/L at Baka for well waters in Parakou commune. The magnesium for well waters in the commune of Parakou is moderately lower (0.22mg/L), unlike that of the waters of the Okpara River (0.55mg/L). Magnesium is among the most common elements in nature. Based on the instructions of WHO (150mg/L) and Bénin (50mg/L), the values obtained are shallow. Therefore, the quality of the water is acceptable for the magnesium and recommended for drinking water. Fig. 13 shows the spatial variation of the magnesium values.

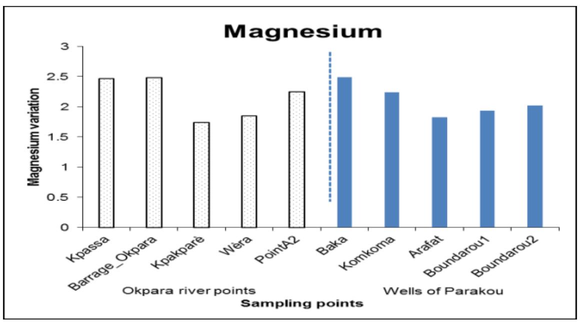

Fig. 13. Spatial variation of magnesium values.

Chemical oxygen demand

The values for this parameter range from 0mg/L for all well waters sampling points in the commune of Parakou to 13.3mg/L for the water at Kpakparè in the Okpara River. The chemical oxygen demand (COD) of the well waters in the commune of Parakou is moderately lower (0mg/L), unlike that of the Okpara River waters (7.55mg/L). The values obtained respect the standards of the WHO (30mg/L) and Bénin (26.2mg/L) for drinking water. Hence, the waters of the Okpara River and well waters in the commune of Parakou pose no risk regarding the chemical oxygen demand and are acceptable for drinking water. Fig. 14 shows the spatial variation of the chemical oxygen demand values.

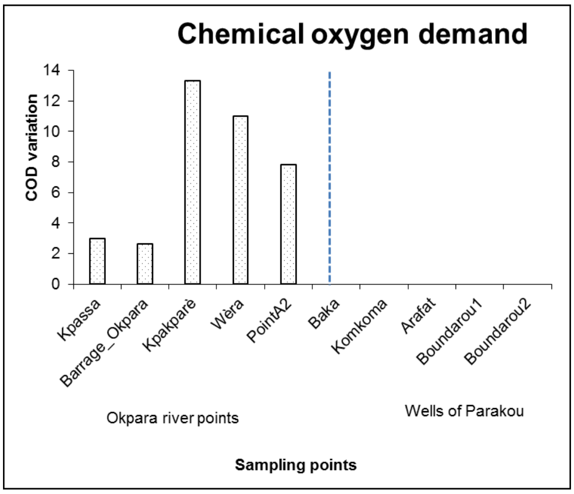

Fig. 14. Spatial variation of chemical oxygen demand values.

Iron

The values of iron range from 0.13mg/L at Boundarou 1 for well waters in the commune of Parakou to 3.25mg/L at Kpakparè compared to the Okpara River. Iron is an essential component of biogeochemical cycles. While the water value of the well waters in the commune of Parakou is moderately lower (0.38mg/L), unlike that of the waters of the Okpara River (2.37mg/L). These values are higher than the standard one of Bénin (0.3mg/L) for which the WHO does not give a cutoff value for drinking water. Therefore, the waters in Okpara River and the Parakou well are not healthy to drink due to the iron content. Fig. 15 shows the spatial variation of iron values.

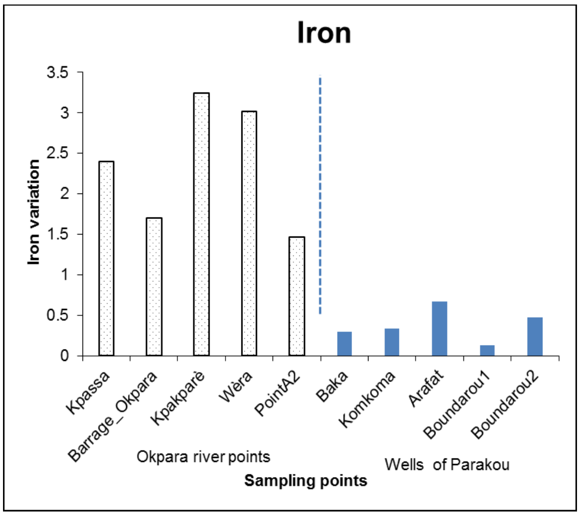

Fig. 15. Spatial variation of iron values.

Chloride

The parameter range from 1.9mg/L at Komkoma to 26.7mg/L at Arafat in the well waters in the commune of Parakou. Hence, the chloride in the well waters in the commune of Parakou is moderately high (13.94mg/L), unlike that of the waters of the Okpara River (4.74mg/L). For drinking water, the contents should be well if it is below WHO standards (≤ 250mg/L) and Bénin standards (250mg/L). Therefore, the waters of the Okpara River and well waters of the commune of Parakou are safe and acceptable. Fig. 16 shows the spatial variation of the chloride values.

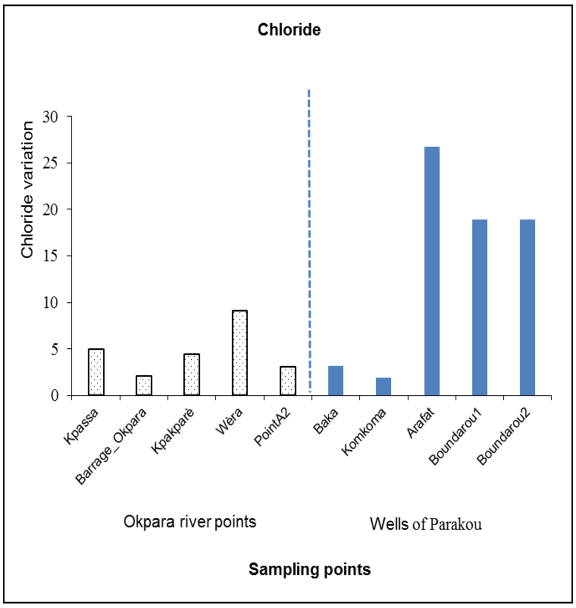

Fig. 16. Spatial variation of Chloride.

Link between variables

To describe the relationships between the different sampling points and to give the characteristics of each group, a Principal Component Analysis (PCA) was carried out in the R version 3.5.0 software. The results of this analysis indicate that the first two significant components concentrate respectively 75.78% and 22.10%, as a total of 97.88% of the variation of the starting table, and is excellent to guarantee a precision of interpretation. The values vary from -1 to 1 on both axes. For example, the figure 17 shows, according to the first principal component that the variables (Wèra, Kpakparè, Point A2, Okpara Dam, and Kpassa) located on the positive side of this axis which is very close, evolving in the same direction. They are opposed to the variables (Baka, Komkoma, Arafat, Boundarou 1, and Boundarou 2), which located on the positive side, resulting in the same direction. In each group of variables, thus constituted move in the same direction, but the two groups of variables to change in opposite directions. Therefore, Okpara River sampling sites are opposed to the Parakou well sampling points.

The analysis of the correlations between the variables and each of the main components (please see Table 2) reveals that Kpassa, Okpara Dam, Kpakparè, Point A2, Baka, Komkoma, Arafat, Boundaraou 1 and Boundaraou 2 are well represented on the first principal component (axis 1) while the variable Wèra well represented on the second primary component (axis 2).

Table 2. Correlations between the input variables and each of the first two main components.

Sites de prélèvement	Dim.1	Dim.2
Kpassa	0.977	0.144
Barrage_Okpara	0.882	0.453
Kpakparè	0.913	0.393
Wèra	0.498	0.821
PointA2	0.836	0.541
Baka	0.972	-0.153
Komkoma	0.917	-0.398
Arafat	0.874	-0.476
Boundarou1	0.869	-0.479
Boundarou2	0.873	-0.474

The analysis of the signs of the correlations of each parameter with each of the principal components indicates:

- On the axis 1, temperature, electrical conductivity, total dissolved solids, nitrate, and chloride oppose the hydrogen potential, dissolved oxygen, chemical oxygen demand and iron in Kpassa, Okpara Dam, Kpakparè, Point A2, Baka, Komkoma, Arafat, Boundaraou 1 and Boundaraou 2.
- On the axis 2, the nitrite, phosphate, and magnesium oppose the calcium in Wèra precisely (Fig. 17).

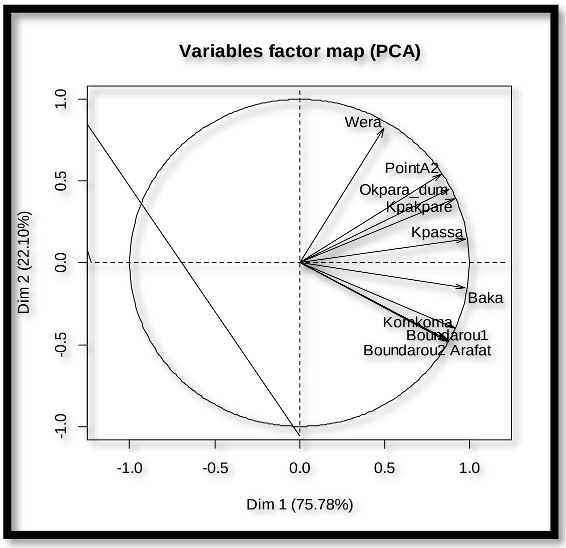

Fig. 17. Correlation circle of the different sampling points.

Discussion

Most of the physicochemical parameters evaluated are not detrimental to consumption, except in some instances where the settings are very high and exceed the standard value. In the waters we have assessed, the temperature of the river waters differs from that of the well waters. However, they are all above the acceptable temperature of WHO (2011) and Bénin (2001), which is 25°C. High temperatures explained by the influence of ambient heat on the collected water. High-temperature values would not be detrimental to human health but pose a problem of acceptability as fresh water is generally more palatable than warm water (Flura *et al.,* 2016). The pH is related to the geological nature of the aquifer formations and the areas crossed (Derradji *et al.*, 2007). The pH values of the well waters in the commune of Parakou and that of the Okpara River follow the WHO standards (6.5 < pH < 8.5) with an average of 6.68 in the well waters and 7.19 in the waters of the river. The river waters used for the study are slightly alkaline because the basic products dumped into the river from the detergents. They are similar to those (Flura *et al.,* 2016) found on the Meghnaghat River (Bangladesh). These values are also consistent with those found in other rivers that cross areas of intense anthropogenic activity (Slim *et al*., 2000).

Dissolved oxygen, which is an important parameter to asses the water quality have lower average values for the waters of the Okpara River and the well waters in the commune of Parakou. It implies that the water is well oxygenated and such water is conducive to the development of aquatic fauna in general and zooplankton in particular. Besides, other points of the Okpara River have shallow oxygen values compared to the standard of 5mg/L, as well as the water from the Parakou wells. Because the aerobic decomposition of organic waste by microorganisms deplete the oxygen contained in those waters. Tepe and Mutlu (2005) related the increase in dissolved oxygen to the high runoff water observed during the rainy season. Moreover, the electrical conductivity measured at the various sampling sites of the river is not as high compared to the standard of 2000µs/cm. As for Wells, the conductivity is not as high but better compared to the river. High values are due to the high concentration of dissolved ions in the water. This phenomenon reported by earlier researchers such as (Kambole 2003; Atibu *et al.,* 2013) who argue that high electrical conductivity also indicates the degree of mineralization of water. The mineralization is a function of the solubility of dissociated compounds, which predicts a high ion content. Ben Moussa *et al.* (2012) stated that low electrical conductivity for a watercourse is also synonymous with low mineralization of salts in the environment. Thus, in the rainy season, it decreases following the dilution of salts and ions due to rainfall. Total dissolved solids (TDS) are equivalent to total mineralization, which is the sum of anions and cations in the water (Kambiré *et al.,* 2014). TDS and electrical conductivity are strongly correlated for this study. The higher the conductivity, the higher is the TDS. This observation is identical for both the river waters and the well waters. According to turbidity, the waters of the Okpara River are more turbid than the waters of the Parakou well. According to the cutoff value of WHO (2011) and Bénin (2001), the average obtained is 73.8mg/L for the Okpara River and 5mg/L for the waters of the wells of Parakou. Hence, the waters of the Okpara River and wells do not show clarity and are cloudy. The nitrate values obtained for the river are between 0 and 1.3mg/L. These values are below the standard of the WHO (2011) and Bénin (2001). Slim *et al.* (2000) found that an infinite amount of nitrate in the surface water is related either to the increased algal growth in these sites or to the common denitrification phenomenon that converts NO_3^- to N_2 through the presence of organic material. For wells, the amount of nitrate ranges from 3.1 to 13.2 as wells are found to be more polluted by nitrate than the river. The origin is probably related to nitrite oxidation by nitrification bacteria following the infiltration of wastewater. As for nitrite, it is almost non-existent in the river. According to Potelon and Zysman (1998), nitrite has an unstable transient form during nitrification or denitrification. Their presence in the natural environment is weak. The concentrations obtained for nitrites are consistent with those of Derradji *et al.* (2007) for surface waters in northeastern Algeria; Mouni *et al.* (2009) for the waters of Wadi Soummam in Algeria. About the well waters, there is almost nonexistent of minerals. The presence of phosphate in the well waters in the commune of Parakou and waters of Okpara reflect some trace. The small amount of phosphate recorded in the waters of Okpara River and the well waters would be related to the period in which the samples had taken, following the standards of the WHO (2011) and Bénin (2001). The calcium and magnesium of the well waters and the waters of the river are well below the normal. It is one of the most common elements in nature. It gives an unpleasant taste to water (2009). According to Nouayti *et al.* (2015) the source of magnesium appears to be related to water contact with limestone and dolomite rocks.

The (COD) did not found in the well waters that we evaluated. Besides, in the waters of the river we find them, but these values do not exceed the standard values of WHO (2011) and Bénin (2001). Iron gives very high values compared to WHO (2011) and Bénin (2001). The presence of large amounts of iron in water is very harmful to the body. There are also high values of iron at the wells, although these values are not as important as the water in the river, exceeding the cutoff values of the WHO (2011) and Bénin (2001). Chlorides are always present in natural waters with variable proportions. All chloride values are below the WHO (2011), and Bénin (2001) standards for drinking water, both for well waters and Okpara River waters and the quantity is also higher at the wells. The comparison of the waters of the Okpara River with those of the wells shows that the majority of the metered parameters lie within the standard range except the iron which is very high on both sides, relating the type of soil which is ferralitic.

Conclusions

The waters of the Parakou wells, as well as those of the Okpara River, have physicochemical contaminations. These contaminations noted by exceeding the standard norm of Bénin (2001) and WHO (2011) of drinking water for the evaluated samples. The analyses carried out have shown that for the physical and chemical properties tested, most waters have high contents, especially for the following parameters: temperature, turbidity, dissolved oxygen and iron, as indicated by the histograms. The pollution, both in physical and chemical, has several origins: domestic, agricultural, and urban, etc. The analyzed waters show a high quantity, with the presence of iron both on the well waters and the river waters. Because all the wells in our study were without copings, and the runoff water can quickly get into the wells as well as dust. The pollution of the river linked to the steady erosion of the study environment and the anthropogenic pollution, including domestic waste. The danger of this chemical pollution is undoubtedly a threat to the people who fetch water for the majority of their needs from these wells and the Okpara River. Hence, the Okpara River water, which is surface water, is more exposed to pollution than the water from the wells of the commune of Parakou through various evaluated parameters.

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Conflict of interest

The authors declare that they have no conflict of interest.

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