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By

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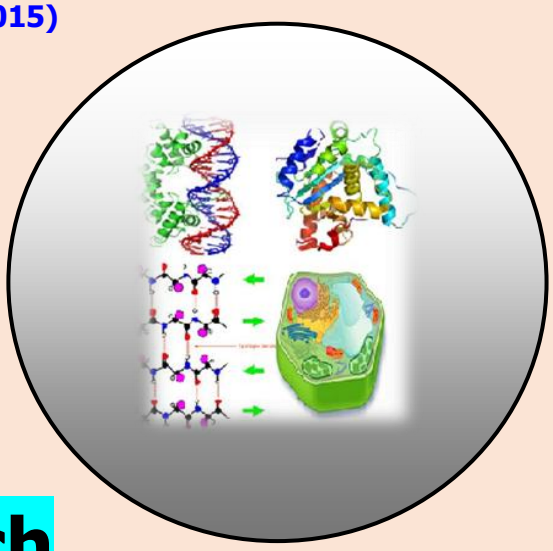

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RESEARCH PAPER

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Physico-Chemical and Bacteriological Characterization of Groundwater Consumed in Rainy Season at Ignié (Congo-Brazzaville) and their Impact on Health

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ABSTRACT

Good quality of driking water is one of most important parameters of public health. In oder to evaluate apotential negative impact in public health of wells water consumed at Ignié, (sub-prefecture of Poollocated arround 45kmfrom Brazzaville), thephysico-chemical and bacteriologic parameters of 20 wellswater were analyzed. The proximative analysis revealed :a strong turbidity and coloration, slightly acid (pH_{mean}5,7); strongconamination inNO_2^-, Cd_2^+, Pb_2^+, Fe_{tot}, Cr_{tot}, Cr (VI) and, apoverty in Na^+, K^+, Mg^{2+}, Cl^-, F^-. Bacteriologi cal analysis shows a strong contamination intotal coliforms :115.65 ± 46.86 UFC/100 mL and Escherichia coli :68.05 ± 27.37UFC/100 mL against 0 UFC/100 mL of WHO standards. These results suggest that wells water of Ignié arepolluted then, unsuitable and requires a treatment before consumption.

Keywords:

INTRODUCTION

Water is a precious resource for the survival of alive beings. With the increasing demand of driking water in the world actually, groundwater becomes an important water supply (Giordano, 2009; Siebert*et al.,* 2010) whichplays a significant rolein many domainsin urban area and rural communities (Eruola*et al.,* 2011 ; Mishraet *al.,* 2002). The World Health Organization (WHO) estimates that 1,5 billion person in the world do not have drinking water of which, approximatively 30.000 dies each day to have consumed a polluted water with arround 35% case of acute gastro-enteritises (GE) due to microorganism (viruses, bacteria and parasits) transmitted by water (O.M.S, 1972). These data revealed the importance of dangers for the health associated with water, and the need of evaluation of the risks of hydrous origin in order to define preventive measures.

Congo-Brazzaville although well equipped by a dense hydrographic networkand a rich ground in water, knows not only problems of approvisionement but alsoof quality of drinking water in urban and rural area(Andzi and Bouaka, 2013a ; Andzi and Bouaka, 2013b). Particularly,in the localities where the surface water resources are limited and those of difficult groundwaters access because of the permeability of the grounds, the situation is more alarming. At Ignié, sub-prefecture of pool located at approximatively 45km from Brazzaville (Congo), because of the non access of surfaces water,groundwaters constitute a source of supply drinking water of the most part of the population.Water of good quality is important in body metabolism and cell functions. However, this quality depends on many parameters such as the presence of substances, metals and organisms (viruses, bacteria and parasits) whom the contents does not exceed the permissible limits ; in the contrary case, it becomea source of several pathologies. Thus, in order to evaluate the sanitary impact of the uses of wells water at Ignié, we proposed to analyze physico-chemical and bacteriological parameters of wellswater in rainy season.The obtained results will make it possible to identify the parameters of pollution and the risks incurred in order to bring to the authorities a tool of decision-making aid to improve the conditions of supply drinking waters of Ignié the populations.

MATERIAL AND METHODS

Sample procurement

Different samples of water used for the study were take away from 20 wells at Ignié (figure 1)at 50 cm depth of the surface of water, by avoidingair penetration.The sample were carefully kept in an isothermal cooler during transport and, at 4°C in the refrigerator before analysis precededby the homogenisation.

Figure 1 : Geographic area of Ignié.

The localisation of various geographical coordonates of water procurementwereread by using aGlobal Positioning System (GPS) type Garmin E-Trex.The read values expressed in UTM (Transverse Universal of Mercator) relate to the latitude (x), longitude (y) and altitude (Z).The data gathered in table 1 represent the average of three readings for each well.

Physico-chemical parameters

The analysis of pH, Temperature, electric conductivity, dissolved total solids (TDS), total hardness (TH_{tot}) and salinity was performed by using amulti parameter analyzer CONSORT C6030. Chemical parameters were analyzed by using photometer Palin test PC 7000 ; oxymeter Lutron C-5510 to evaluate dissolved oxygen.Turbidity was given by a turbidimeter Aqua lytic compact PC CD vario.All these physico-chemical parameters were performed according to Apha-awwa-wpcf (1994)method(APHA-AWWA-WPCF,1994).A camera Sony (HDR, PJ200, 5.Méga Pixels, 7,2V, 30Xextended zoom) were brought on the ground for images.

Table 1. **Codes, GPS coordonnates of each point of water.**

Water points	Code	Latitude (x) UTM	Longitude (y) UTM	Altitude (z) UTM
Well 1	W_1	9560016	542377	705
Well 2	W_2	9560026	542422	716
Well 3	W_3	9559972	542446	716
Well 4	W_4	9560120	542548	723
Well 5	W_5	9560120	542584	724
Well 6	W_6	9560108	542590	725
Well 7	W_7	9560120	542652	717
Well 8	W_8	9560090	542647	717
Well 9	W_9	9560100	542660	718
Well 10	W_{10}	9560096	542725	719
Well 11	W_{11}	9560050	542478	717
Well 12	W_{12}	9560082	542497	721
Well 13	W_{13}	9560128	542547	724
Well 14	W_{14}	9560086	542496	717
Well 15	w_{15}	9560088	542679	714
Well 16	W_{16}	9560066	542727	714
Well 17	W_{17}	9559818	542480	718
Well 18	W_{18}	9559798	542472	720
Well 19	W_{19}	9559804	542439	722
Well 20	W_{20}	9559776	542380	723

Bacteriological parameters

Bacteriological parameters was evaluate according to standard method (RODIER, 2003).The main part ofused materials are :Magnetic Agitator Withe withhotplateIKA RCT (Basic, safety control);Bechers, Erlenmeyer; Petri box, spatule and Mary bath ; Autoclave (TRAUN/ASTRIA) ; Eprouvets, flasks, graduatedpipettes (Brand Interna) ; Burner and incubator, Pasteur furnace, etuve (WTW,U.E).

Statistical analysis

Software STATISTICA 7.1 was used for processing the data andmultivariate analysis of results.

RESULTS

Physico-chemical parameters

Table 3 presents the results of physical quality and organic matter compositionof the samples. It appears that the values oftemperature are included between 27.50 and 28.60°C with an average of 28.14 ± 0.38°C correspondent to an increase of 03 ± 0,38°C compared to the standard (norms). ThepH values are between 5,18 and 6,33 for an average of 5.70 ± 0.34, compared to the standard there is an descrease of2.8.Average of turbidity is 11.39 ± 9.98 mg/L correspondent to an increase of 6.39mg/L,exceeds largely thestandard.Electrical conductivityand salinity with278.15 ± 135.09µS/cm and 0.14 ±0.07mg/Lrespectively are lower than standards. TheTDS values is 148.13 ± 71.92mg/L.

Table 4 belowrevealed that inorganic nitrogen contents of wells water are very weak and, vary between 0.50 and 17mg/L of $NO3^-$;0.14 and 0.80mg/L of $NH4^+$.These contents are lower than WHO standards ; whereas the $NO_2^-$with 0.30 ± 0.06 mg/L exceeds largely the guides value of WHO (0.1mg/L).

Table 3. Caracteristic parameters of physical aspect and organic matter tested in wells water.

Parameters	Mean	Median	Minimum	Maximum	Variance	Ecart-type	Norms
T (°C)	**28.14**	**28.25**	**27.50**	**28.60**	**0.15**	**0.38**	**12-25**
pH	**5.70**	**5.75**	**5.18**	**6.33**	**0.11**	**0.34**	**6.5-8.5**
C.E (µS/cm)	**278.15**	**264.50**	**96.70**	**564.00**	**18249.72**	**135.09**	**400**
TDS (mg/L)	**148.13**	**141.00**	**51.50**	**300.00**	**5172 .71**	**71.92**	**/**
Salinity (mg/L)	**0.14**	**0.10**	**0.10**	**0.30**	**0.00**	**0.07**	**0.5**
Turbidity (NTU)	**11.39**	**9.35**	**2.20**	**47.00**	**99.57**	**9.98**	**<5**
Color (mg/LPtCo)	**87.50**	**83.50**	**10.00**	**210.00**	**2890.58**	**53.76**	**15**

Table 4. Mineralnitrogen parameters of groundwater.

Parameters	Mean	Median	Minimum	Maximum	Variance	Ecart-type	Norms
NO_3^- (mg/L)	5.56	2.20	0.50	17.20	35.13	5.93	50
NO_2^- (mg/L)	0.30	0.29	0.21	0.42	0.00	0.06	0,1
NH_4^+ (mg/L)	0.44	0.46	0.14	0.80	0.04	0.21	0,5

Table 5. Alcalinity and fundamental elements.

Parameters	**Mean**	**Median**	**Minimum**	**Maximum**	**Variance**	**Ecart type**	**Norms**
TAC (mg /L $CaCO_3$)	**40.70**	**40.50**	**32.00**	**45.00**	**10.64**	**3.26**	**30**
THt (mg /L $CaCO_3$)	31.70	31.50	14.00	57.00	123.38	11.11	50
Ca^{2+} (mg/L)	12.20	11.50	4.00	24.00	28.69	5.36	100
HCO_3^- (mg/L)	49.65	49.41	39.04	54.90	15.84	3.98	125-350

Table 5 shows that complete alcalimetrictitle (TAC) presents an averageof 40.70 ± 3.26 mg/L. These value is more higher compared to the standard (30mg/L). Hydrotimetric title (THt) remains in the standards (50 mg/L) with an average of37.70 ± 11.11 mg/L of $CaCO_3$.

Table 6 presents anions, metal and nonmetal cations composition. The rates of $Cr_{tot}$is 0.22 ± 0.08 mg/L against 0.05 mg/L; $Cr_{(VI)}$ 0.35 ± 0.33 mg/L against 0,05 mg/L ; Pb^{2+}0,76 ± 0,42mg/L against 0,01 mg/L and finally the Cd^{2+} 0,11 ± 0,02mg/L against 0,003 mg/L. All theses values exceeds largely the standards values. Whereas others elements values are lower than satandards.

Bacteriological parameters

Table 7 presents the results of bacteriologic analysis.The average rate of total coliforms is 115.65 ± 46.86 UFC/100 mL of water. The same situation is observed with *Esherichia coli* with an average of 68.05 ± 27.37 UFC/100 mL. These values results are largely higher than the of WHO standards that fixed at 0 UFC/100mL of water.

Table 6. Rates ofmetallic and non metallic ions.

Paramètres (mg/L)	**Mean**	**Median**	**Minimum**	**Maximum**	**Variance**	**Ecart-type**	**Norms**
O_2 dis.	7.93	8.10	7.10	8.70	0.28	0.53	/
Na^+	7.42	5.95	0.07	20.97	28.86	5.37	200
K^+	3.99	3.15	1.80	7.00	3.07	1.75	10
Mg^{2+}	10.25	9.00	3.00	22.00	24.20	4.92	50
Fe^{2+}	0,21	0,12	0.06	0.62	0.03	0.17	5-50
Cd^{2+}	**0.11**	**0.11**	**0.05**	**0.17**	**0.00**	**0.02**	**0,003**
Pb^{2+}	**0.76**	**0.64**	**0.17**	**1.69**	**0.17**	**0.42**	**0,01**
Al^{3+}	0.07	0.07	0.01	0.17	0.00	0.03	0,2
F^-	0.73	0.73	0.28	1.32	0.05	0.23	1,5
Cl^-	9,75	10.35	3.00	13.00	6.48	2.55	250
SO_4^{2-}	18.86	16.70	7.70	34.70	52.62	7.25	12-25
PO_4^{3-}	0.71	0.50	0,26	2.20	0.26	0.51	5
SiO_2	13,80	13.80	8,90	19.90	11.25	3.35	/
Fe_{tot}	**0.49**	**0.39**	**0.17**	**1.60**	**0.14**	**0.37**	**0,3**
Mn_{tot}	0.49	0.50	0.17	0.80	0.04	0.19	0,5
$Cr_{tot.}$	**0.22**	**0.20**	**0.13**	**0.39**	**0.01**	**0.08**	**0,05**
$Cr_{(VI)}$	**0.35**	**0.16**	**0.10**	**0.90**	**0.11**	**0.33**	**0,05**
Bore	0.00	0.00	0.00	0.00	0.00	0.00	0,5
Cu_{tot}	0.51	0.48	0.28	0.74	0.02	0.14	2

Table 7. Sample bacteriologicparameters in rainy season.

Parameters UFC/100mL	**Mean**	**Median**	**Minimum**	**Maximum**	**Variance**	**Ecart-type**	**Norms**
Total Coliforms	**115.65**	**100.50**	**60.00**	**215.40**	**2195.40**	**46.86**	**0**
E. coli	**68.05**	**69.00**	**15.00**	**107.00**	**749.21**	**27.37**	**0**

DISCUSSION

The strong current demography in the world lead an increasing needs ofdrinking water. Thus, the identification of pollution parameters of driking waterbecome the most important research way to prevent sanitary riks against hydrous deseases.In this study, the obtained results revealed that temperature one of significant factor for physico-chemicalvariation and development of bacteriais higher than the norms. The founded temperatures (28.14 ± 0.38°C) is generally responsible of the proliferation of mesophiles bacteria such as coliforms. Thesehypothesis is confirmed by the value of pH which showed that groundwater at Ignié is slightly acid and would support the proliferation of coliforms responsible of several hydrous diseases. Also, aparthydrous diarrhoea, bacteriogical proliferation could be at the origin of the formation of harmful compound for human being as Trichloracetic acids (HAAs) during disinfection by chlorination (Reckhow and Singer,1985).This acidity would probably come from the decomposition of vegetable organic matter very abundant in the study's area wich is confirmed by the strong colouring and turbidity of water. This state can lead to a considerable increase of chlorine doses during the treatment of water, being able to provoke a substantial production of organohalogen compounds (Hongyan*et al.,* 2014 ; Margerum *et al.,* 1974), because chlorine reacts with organic matter contained in water, even with a low dose (5 mg/L) (Zhang*et al.,* 2000).

The organic presence of matter in water is an indirect indicator of bacteriological risk. Thus, during disinfection with chlorine in particular, it can provoke the formation of undesirable products such as TriHaloMethane (THM) or the bad taste of water in the origin of others patologies (Aysegul, 2003).Moreover, the results show that recorded conductivities are rather strong, although, lower than WHO standards, that corresponds to a good mineralisation of water.Whereas the NO_2^-(0.30 ± 0.06 mg/L) exceeds largely the guides value (0.1mg/L). Nitritecan fixed on haemoglobin at the place of oxygen and cause respiratory difficulties (asphyxiates) :the methemoglobinemie (cyanosite)which touches primarily new borns or fœtus and presents sanitary risk at short-term (Krasner*et al.,* 1989). At the time of potabilisation of water by chlorination, the nitrogenized compounds could react with chlorine, to form monochloroamins compounds, responsible of bad smells of water, by the formation of amino acids (Massoumou*et al.,* 2014).The analysis of compared values confirm the presence of hydrocarbonates ions (HCO_3^-) in water. Whereas this water may contains weak concentrations of Ca^{2+} ; what confirms their low hardness. One notes that the majority of analyzed ions, are lower values than WHO standards, excepted for Cd_2^+, Pb^{2+}, Fe_{tot}, Cr_{tot} and $Cr_{(VI)}$. Indeed, metals such as Pb^{2+},Cd^{2+}, Fe_{tot}, Cr_{tot} and $Cr_{(VI)}$, represent a particular form of chemical pollution, thus the obtained results from analysis indicates a specific risks of pollution. This form of pollution still in the origin of intoxications: disease of Minamata in Japan and Guyana (mercurial derived), disease Itaï-Itaï (cadmium). Indeed, even at low dose they can accumulate and become responsible in a long-term of pathologies affecting nervous system, kidney, liver and skeleton. Consumed water of Ignie are subject to these kinds of pollution. .An analyse of these values confirm a serious problem of sanitary risks of the users of wells water at Ignié. $Pb^{2+}$is extremely toxic and nephrotoxically horrible. This metal can be responsible of cancerous, saturnism. Whereas iron gives a reddish color and a bad taste to water. $Cr_{(IV)}$is responsible of several types of cancers (. O.M.S., 1994 ; Richardson*et al.,* 2007). These metals are generally spilled by industries or ground laundering on which various pollution related to traffic, heating, domestic garbage. It can accumulate in rivers, lake, well and, thus reach the flora and watery fauna (shells, fish). In water, $Cr_{(IV)}$ reduce significantly the content in oxygen. The content in dissolved oxygen in water is one of most important indicator of the degree of water pollution and, it takes an important part in the majority of chemical and biological processes.In our case, table 6 present a lower contents in dissolved oxygen (7.93 ± 0.53 mg/L) indicating a strong chemical and biological activity that confirm the sanitary risks.

Bacteriologic analysis come to confirm the emitted hypothesis of proliferation of bacteria in the first(temperature, pH and organic matter). Indeed, since always, the existence of infectious hydrous diseases of enteric origin (related to intestines) is conveyed by worn and surface water.These agents can be of bacterial origin (salmonellas, shigelles, *Escherichia coli* and bacilli coliformes, vibrios choleraic, *Legionella*, etc…) or viral.*E. coli* are currently at the origin of true food epidemics (haemolytic and uraemic syndromes).Their excretion by people or especially by bovines, could explain the contamination of implied food.In our case, this contamination can come, either of a surface water infiltration in the wells, or of a water remained stagnant.Atrains time, fecal coliforms or *Enteroccocus* from faeces, manures, septic tanks and latrins (Hartemann,1989),located in the neighbourhoods of studies well can be bring in wells by ruisselement and be in the origin of contamination.The presence of poultries and small porcin and bovin units of breeding can also explain these contaminations.Indeed cited animals are potentials hosts of several bacteria and virus, frequently observed in polluted water, in particular, the enterovirus (such as the polioviruses), but also Coxsackie virus and the Echoviruses, persons in charge for gastro-enteritises and neuro-meninges syndromes(Haas,1983). In general, these bacteria are particularly resistant in the environment and treatments ; property shared by many others parasits as *Entamoeba histolytica*, *Giardia lamblia* and *Cryptosporidium parvum*, whose cysts, resistant to disinfecting, can survive very a long time in water.

CONCLUSION

Physico-chemical and bacteriological analysis of wells water consumed at Ignie, showed that groundwater is water of very bad quality and likely to be at the origin of hydrous diseases.It appeared that this water does not respect the WHO standards necessary to the potabilisation of a water.One notes the presence of a pollution to heavy metals ($Pb2^{+}$, $Cr4^{+}$, $Cd2^{+}$, Fe_{tot}) and to the bacteria (total coliforms and *E coli*).This pollution would be of natural origin (composition of the grounds) and, also of exogenic origin. They are turbid, aggressive, odors rotted, hard and mineral-bearing thus, a treatment is necessary before their consumption.

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