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RESEARCH ARTICLE

Comparative Study of Physical and Bacteriological Analysis of Borehole Water in Kogi State

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Abstract

Water is an essential part of human existence. It is universally utilized for various purposes ranging from drinking to other domestic purposes. The need for access to water has been a significant challenge for governments all over the world. In Nigeria, there is a growing concern about the water shortage in various communities across the country. In a bid to overcome water scarcity, the government provides boreholes in many places. However, the inadequacy of functional public boreholes has led to the proliferation of private boreholes across the country, which the quality is doubtful. The purpose of the present study was to compare the physical and bacteriological compositions of the public and private boreholes in Kogi state, Nigeria. A total of ten water samples were collected from different public and private boreholes in three locations in the state. Standard procedures were followed in analyzing the samples. The analysis revealed the presence of *salmonella spp*, *Escherichia coli*, *pseudomonas aeruginosa* in the private boreholes.

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Introduction:-

Water is a universal solvent, which consists of hydrogen and oxygen atoms and plays a critical role in all known geological and biological processes (Bistri & Reinaud, 2015; Conti Nibali et al., 2020; Dhakane et al., 2014; Dirican, 2014; Hussain et al., 2020; Knight et al., 2019; Perlman, 2018; Pohorille & Pratt, 2012; Reichardt & Timm, 2020; Shen et al., 2021). It is a chemical substance with two hydrogen atoms and one oxygen atom in each of its molecules (Saxena et al., 2020). hence the molecular formula is H₂O. (Viscopedica, 2016). It is formed by the direct reaction of hydrogen with oxygen. Water is colorless, odorless, and tasteless liquid in its pure form (Saxena et al., 2020). It is an inorganic substance in all three of its states, including liquid, gas, and solid (Senthil Kumar & Yaashikaa, 2019).

Water is essential for metabolism, substrate transport across membranes, cellular homeostasis, temperature regulation, and circulatory function (Armstrong & Johnson, 2018). It is considered an essential element for the survival of all living beings (Garrido, 2020). According to D'Odorico et al. (2020), every critical environmental function and human needs critically depend on water. This assertion points to the crucial importance of water to human survival. However, many people do not have access to clean and safe drinking water, and many die of waterborne bacterial infections (Cabral, 2010). Water dominates most of the space on our planet, covering about 71% of the earth's total surface area (Kumar & Yaashikaa, 2019). it is found mainly in oceans and other large water bodies. Water on earth moves continually through a cycle of evaporation, transpiration, precipitation, and runoff, usually reaching the sea (Bhat & Tariq, 2014; Lewis, 2020).

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Clean and fresh drinking water is essential for humans and other life forms (Hodgson, 2019; Rashmi Reddy et al., 2010; Rogers, 2008; Swaroop et al., 2010). Access to safe water is crucial in determining the environmental sustainability, public health, and economic prosperity of any nation (Wee & Aris, 2019). However, lack of access to safe drinking water remains a concern in many developing countries, mainly rural areas. (Schäfer et al., 2014). For instance, (Erhuanga et al., 2021) noted that most households in Nigeria lack access to safe drinking water. And Nigeria's hygienic and healthy water situation is not very promising (Kankara & Bazza, 2016). Extensive literature has emphasized the inadequate availability of safe drinking water in Nigeria (see Adeneye et al., 2016; Akpor & Muchie, 2011; Horne et al., 2019; Igbinsosa & Osemwengie, 2016; Ogbonna et al., 2020; Raji et al., 2010; Sridhar et al., 2020; Yachim et al., 2020). Thus, suggesting the need for sustainable, safe water intervention to mitigate the adverse effects of contaminated water. Perhaps, the importance of developing effective water supply services is universally recognized as a basis for improving the population's overall health (Badejo et al., 2015). The present study is aimed to analyze the physical and bacteriological compositions of borehole water between dry and rainy seasons.

The quality of drinking water has attracted significant attention worldwide because of implied public health impacts (Barakat et al., 2018; Damo & Icka, 2013; Elsayed Gabr et al., 2021; Ibrahim, 2019; Li & Wu, 2019; Maleki et al., 2018; Nurtazin et al., 2020; Thapa et al., 2019; Thoidingjam et al., 2020). The water quality index (WQI) is a valuable and unique rating to depict the overall water quality status that is helpful for the selection of appropriate treatment techniques to meet the concerned issues (Badejo et al., 2015; Tyagi et al., 2020). Underground borehole water is a common source of water supply for most households in Nigeria. The lack of pipe-borne water has prompted many people to resort to digging boreholes across the country. Although boreholes provide access to abundant water, there is a growing concern about the quality of water from boreholes (Foka et al., 2018; Ibe & Okpinye, 2008; Nnaji et al., 2019; Olalekan et al., 2015). However, findings from studies on the contamination of borehole water in Nigeria have been contradictory (Adogo et al., 2016; Gyang et al., 2017; Ibo et al., 2020; Oguntoké et al., 2009; Simon-Oke et al., 2020). There is a growing concern about the proliferation of private boreholes across the country. Perhaps, insinuations suggest that public dug boreholes are safer relating to water quality than private boreholes (Okon, 2013). The primary purpose of the present study is to compare the physical and bacteriological compositions of public and private boreholes water sources in Kogi State, Nigeria.

Materials and Methods:-

Collection of Samples

Water samples were collected from ten different boreholes dug by the public (state or federal government) and the private (individuals, missionaries, NGO, organizations) in Ankpa, Ajaokuta, and Lokoja in Kogi state. The samples were collected using well-sterilized containers. The collected samples were sent to the laboratory immediately. The materials for the study were adequately cleaned and sterilized in a hot air oven, and the media was aseptically prepared according to the manufacturer's instructions.

Method of Analysis

Analysis of the water samples was carried out by physical analysis and bacteriological analysis. The physical examination included the determination of the water turbidity. The physicochemical parameters comprising the water temperature, pH, and electrical conductivity were assessed using the standard procedure (APHA 2012) described. The mercury-in-glass bulb thermometer was used to measure water temperature ($^{\circ}\text{C}$). Also, the Hanna Instrument meter (Model H19813-6) previously calibrated with buffer solutions was adopted to assess the pH, while conductivity was ascertained with a conductivity meter calibrated with potassium chloride solution. The bacteriological analysis was conducted using the procedure described in the manual of clinical microbiology (Jorgensen & Pfaller, 2015)

Results:-

The boreholes were identified by alphabets, with A- E representing the private boreholes while F – J signifies the public boreholes. Thus, table 1 shows that there were no changes in the color and odor of the samples. Still, there were changes in the samples' pH, turbidity, and conductivity on the private borehole waters (A, B, C, D, E), while there are no changes on the public borehole (F, G, H, I, J). Table 2 shows the total plate count of coliform on the nutrient agar, MacConkey agar, and Eosin methylene blue agar at 37°C in 24 hours. Table 3 shows that there was acid and base on the private borehole samples (A, B, C, D, and E) while there was not acid or gas on the public borehole water sample (F, G, H, I, and J). Table 4 shows the presence of acid and gas on the private borehole water sample (A, B, C, D, and E) when mixed with 10ml double strength, 5ml single strength, and 1ml single strength. At

the same time, there was no acid or gas on the public borehole water samples (F, G, H, I, J) when mixed with 10ml double strength, 5ml single strength, and 1ml single. Table 5 shows the growth on the private borehole waters (A, B, C, D, and E), which is positive, while there was no growth on the public borehole water (F, G, H, I & J) water which is negative. Table 6 shows that there was bacteria growth on the private borehole water (A, B, C, D, and E), which is positive, while there was no growth at all on the public borehole water (F, G, H, I and J) which is negative.

Table 1:- Table showing the physical analysis.

Parameter	SAMPLES									
	Public Borehole					Private Borehole				
	A	B	C	D	E	F	G	H	I	J
Turbidity (NTU)	+	+	+	+	+	-	-	-	-	-
Odor (TCU)	-	-	-	-	-	-	-	-	-	-
Conductivity P/cm	4.5 x10 ²	4.0x10 ²	3.7 x 10 ²	2.8x10 ²	3.4x10 ²	3.4x 10 ²	2.8x 10 ²	3.4x10 ²	4.5 x10 ²	4.0x 10 ²
Ph	5.7	6.0	6.2	6.1	6.0	6.5	6.5	6.6	6.6	6.5

Key:

- = Negative,

+ = positive

Table 2:- Bacteriological Analysis Total plate count of vital coliform at 370C in 24hours for pathogenic organisms in public and private boreholes. (CFU/ml).

Samples of water	Nutrient agar	MacConkey agar	EMB Agar
A	20	36	45
B	40	50	55
C	10	30	46
D	20	20	25
E	10	40	30
F	0	0	0
G	0	0	0
H	0	0	0
I	0	0	0
J	0	0	0

Keys

A = private

B = private

C = private

D = private

E = private

F = public

G = public

H = public

I = public

J = public

Table 3:- Most probable number count for water sample (public and private boreholes).

Water Sample	Double strength		Single strength	Sample Count	MPN
	10ml	5ml	1ml		
A	3		3	3	>1100
B	3		3	3	>1100
C	3		3	3	>1100
D	3		3	3	>1100
E	3		3	3	>1100
F	0		0	0	< 3
G	0		0	0	< 3
H	0		0	0	< 3
I	0		0	0	< 3
J	0		0	0	< 3

Keys

A = private B = private
 C = private D = private
 E = private F = public
 G = public H = public
 I = public J = public

Table 4:- Presumptive Test.

Samples number	10ml double strength	5ml single strength	1ml single strength
A	AG	AG	AG
B	AG	AG	AG
C	AG	AG	AG
D	AG	AG	AG
E	AG	AG	AG
F	-	-	-
G	-	-	-
H	-	-	-
I	-	-	-
J	-	-	-

Keys

A = private B = private
 C = private D = private
 E = private F = public
 G = public H = public
 I = public J = public
 AG = Acid and Gas
 - = Negative

Table 5:- Confirmatory Test Table.

Samples number	10ml double strength	5ml single strength	1ml single strength
A	+	+	+
B	+	+	+
C	+	+	+
D	+	+	+
E	+	+	+
F	-	-	-
G	-	-	-
H	-	-	-
I	-	-	-
J	-	-	-

Keys

A = private B = private
 C = private D = private
 E = private F = public
 G = public H = public
 I = public J = public
 + = Positive
 - = Negative

Table 6:- Completed Test.

Samples number	10ml double strength	5ml single strength	1ml single strength
A	+	+	+
B	+	+	+
C	+	+	+
D	+	+	+
E	+	+	+

F	-	-	-
G	-	-	-
H	-	-	-
I	-	-	-
J	-	-	-

Keys

A = private	B = private
C = private	D = private
E = private	F = public
G = public	H = public
I = public	J = public
+ = Positive	
- = Negative	

Table 7:- Biochemical test for identification of bacteria.

Samples	Gram staining	Citrate	Catalyst	Indole	Oxidase	Methyl red	Urease	Motility	Spore reaction	Sucrose	Lactose	Glucose	Micro-organisms
Sample A	-	-	-	-	+	+	-	+	-	-	-	AG	<i>Pseudomonas aeruginosa</i>
Sample B	+	-	+	+	-	+	-	+	-	A	A	A	<i>Escherichia coli</i>
Sample C	-	+	-	-	-	+	-	+	-	+	+	+	<i>Salmonella spp</i>
Sample D	+	+	-	+	+	-	+	+	-	+	+	+	<i>Pseudomonas aeruginosa</i>
Sample E	-	-	+	+	-	+	-	+	+	+	+	+	<i>Salmonella spp</i>

Keys

A = private	AG = Acid and Gas
B = private	+ = Positive
C = private	- = Negative
D = private	E = private
	G = Gass

Discussion:-

The study was conducted to compare the physical and bacteriological compositions of the public and private borehole water sources in Kogi state. The specific objective of the research was to examine the difference between the public and private boreholes based on their physical and bacteriological constituents. From table 4 above, the coliform confirmed on the individual sample had more than five total coliforms per 100ml in private borehole water. When water contains coliform bacteria in levels greater than one per 100ml of water, they may also contain pathogens that cause acute intestinal illness. While generally considered a discomfort to the health, these infections may be fatal to infants, older adults, and those who are sick. Still, in table 4, there was no coliform on the public borehole water, thereby making it free from contaminants.

More so, the presence of salmonella spp, *Escherichia coli*, *pseudomonas aeruginosa* was detected at a high level in the private borehole water, as shown in table 7. This indicates that the privately owned boreholes are most polluted with coliform bacteria. The presence of these bacteria signifies that the water is not suitable for human consumption. This finding corroborates the study (Okon, 2013) which found the high composition of coliform bacteria in privately dug boreholes. The complete absence of organisms in the public borehole water samples might be attributed to the fact that some forms of treatment are usually applied to the supply by the government. The variation in the physical and bacteriological composition of the boreholes examined could be attributed to the poor depth of the private borehole and lack of supervision of the drilling process of private boreholes.

Conclusion:-

The study aimed to compare public and private borehole water in Kogi state, Nigeria. The analysis performed on the collected water samples from the boreholes established the presence of micro-organisms in the private borehole water sources. In all, the experiment indicates that water from the private boreholes examined is not safe for human consumption and could pose a danger to human health. The study recommends robust examination and treatment of private boreholes in Kogi state.

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