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AN ASSESSMENT OF PHYSIOCHEMICAL PROPERTIES OF UNDERGROUND DRINKING WATER IN KAFANCHAN, KADUNA STATE

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ABSTRACT

This study assessed the physiochemical properties of underground drinking water in Kafanchan township, Kaduna State. The study is aimed at determining the physiochemical and biological parameters of drinking water from underground sources – hand dug wells and boreholes in Kafanchan. The analytical research design was adopted for the study. The target population for the study includes residents of all the five wards who have either hand dug well or borehole in their houses as the main source of drinking water in the study area. A total of 15 water samples were taken, 10 from hand dug wells and 05 from boreholes. These samples were analyzed using appropriate procedures. The Physiochemical properties tested include P^H, Temperature, Turbidity, TDS, Electrical Conductivity, Color, Nitrates, Fluoride, Chloride, Alkalinity, Phosphate, Sulphate and Hardness. The purposive random sampling was employed to collect samples from each of the five wards. Results obtained were subjected to mean, standard deviation, standard error of means and one sample t-test. Analysis of variance – ANOVA was determined and $p< 0.05$ was considered to indicate significance. Results obtained from analysis showed that Turbidity values of (10) and Fluoride values of (1.5) were found to exceed the maximum permissible limit recommended by World Health Organization (WHO) and NSDWQ. Also, results showed that the highest values of mean for Nitrates (8.97mg/l) were recorded in Maigizoh ward while the lowest values of mean for same (3.53mg/l) recorded in Kafanchan B ward which is significant at p< 0 .05 alpha levels but are below the permissible limits. The total dissolved solids also showed significant difference at p< 0.05 alpha level with highest values of 272.67mg/l recorded in Kaninkon ward, while lowest the values of 98.67mg/l recorded in Kafanchan A ward but the overall result was below the permissible limit of WHO and NSDWQ. The study concluded that Kafanchan underground sources of drinking water are averagely safe except for the high turbidity which is an indication of the presence of microbial organisms commonly found in hand dug wells. The study recommended that further investigations should be made on other sources of domestic drinking water especially from pipe borne and streams/surface flowing water to determine their level of contaminations which may be the major source of water borne diseases in the study area.

Keywords: *Underground water, Physiochemical properties, Permissible limits, Significance, WHO, NSDWQ.*

INTRODUCTION

Water is a necessity for the survival of man and other living organisms and obviously the second most important resource after air (Nagamani, 2015). It is the only known substance to occur as liquid, solid and gas at varying temperature. It is important to recall that 71% of the earth surface is covered by water of which 97% of this71% is saline and found in oceans and seas and the remaining 3% as freshwater. 68.7% of the fresh water is locked up as glaciers and icecaps, 30.1% as groundwater, 0.9% others and 0.3% as surface water. Furthermore, 87% of this surface water is found in Lakes, 2% in rivers and 11% in swamps. Therefore, it is safe to say water availability for consumption is grossly inadequate especially in developing countries for example, Nigeria (Sabrina, 2013). The provision of potable water is particularly important in developing nations such as Nigeria, the states and even the communities such as Kafanchan. Hence the principal element in water use is not just on water availability and accessibility but also on water quality.

Water quality refers to the state of its physical, chemical and micro – biological properties in relation to its hydrological properties (Irfan et al., 2014 in: Muhammad Aamir, 2014). Water is often allocated for different uses; therefore, different water use will require different level of assurance. The major concern in terms of water quality is the rapid decline of fresh usable water (Irfan et al., 2014). Musa, Adamu and Mohammed (2016) stated that the safety of drinking water is affected by various contaminants which include heavy metals, waterborne diseases and other micro-biological organisms due to increase in population, urban growth and development, drastic anthropogenic activities to mention a few. Furthermore, Nagamani (2015) reported that 3.1% of deaths and 3.7% of disability-adjusted-life-years worldwide are attributed to unsafe drinking water. Earlier on, Morrison (1993) reported that about 10-20 million children who die each year of diseases associated with diarrhea. Similarly, Ajao, Obafemi and Ewumi (2011) observed that unhygienic sources of drinking water have been the major causes of waterborne diseases such as onchocerciasis, typhoid fever, cholera, dysentery, gastrocenteritis, and other parasitic ingestions.

Kafanchan water system was initially constructed to supply water to the initial settlement which cover only Kafanchan wards A and B. over the years, this water system could not cope with the growth of population which led to the expansion of surrounding villages of Takau, Kaninkon and Maigizoh growing into larger settlements in which the water system could not reach until date. Thus, majority of in habitants of these outskirt have to rely solely on underground water (wells and boreholes) as the main source of supply for drinking and other domestic uses.

Assessing underground water quality which is the main source of drinking water in Kafanchan town is necessary in view of the number of mortality due to water related diseases in the study area.

STATEMENT OF THE PROBLEM

Water is one of the most basic of human needs; however the reality is that it remains one of the cancerous problems successive governments have battled to address due to rapid population growth especially in developing countries, Nigeria and indeed the study area inclusive. A lot of researches have been conducted by scholars such as Sabrina (2013), Nagamani (2015), Balogun (2017), Morrison (1993), Ajao, Obafemi and Ewumi (2011) and a host of others on water quality for domestic and industrial uses for sustainable development. Researchers' recommendations on how to improve water quality for domestic and industrial uses were implemented by successive stakeholders and decision makers but the problem still persist in Kafanchan and other places. Existing literatures shows that research of this type has not been carried out in Kafanchan on domestic groundwater in use which form the major source of domestic water supply source, the findings made here is intended to cover this gap.

Aim of the Study

The aim of this study was to determine the physiochemical properties of domestic groundwater in Kafanchan, Jema'a Local Government Council, Kaduna State. The study specifically assessed the water quality index (WQI) of underground water in the study area; also the study examined the physiochemical properties of the underground water vis – a – vis WHO, and NDWSQ permissible standards. Finally, the study suggested ways of improving upon existing efforts for sustainable water quality standards permissible for drinking.

Research Hypothesis

The following hypothesis is presented as specific statement of prediction to evaluate the research questions. **H_o**: There is no significant difference between the underground water quality in Kafanchan and the WHO, NDWSQ permissible standard.**H_1**: There is significant difference between the underground water quality in Kafanchan and the WHO, NDWSQ permissible standard. The hypothesis was tested at 0.05 alpha level of significance.

Significance of the Study

Concerns are still growing due to poor accessibility to potable water supply in Nigeria and other parts of the world. Ishaku et al. (2011) observed that lack of potable water supply or its poor quality could result into outbreak of waterborne diseases, which causes deaths and diversion of financial resources to disease treatments and prevention. From the perspective of these concerns, most governments of developing countries continue to have a task in making potable water supply feasible in cities, towns and villages. This study is significant because none of the literatures and other studies reviewed, focused on Kafanchan underground water quality. This study will widen the general public knowledge on the quality of groundwater supply providing useful information for stakeholders and researchers on the state of underground water quality in Kafanchan.

LITERATURE REVIEW

Water has an undisputable value to people and communities, adequate safe water and sanitary services potentially guarantee good health and improved lives of people. According to Omaga (2019) water play important role by providing various opportunities to rural communities in terms of businesses, agriculture, local consumption and infrastructural development. There are a variety of water sources, including oceans, rivers, springs, dams, wells, and boreholes that meet the needs of individuals and communities as well as impact socioeconomic development. The protection of these water bodies is therefore, important and necessary for the good of people and communities (Ishaku et al., 2011). Sanusi et al., (2010) discovered that the growth of Minna town in Niger State, Nigeria outstretched the initial water system originally designed to cover. Thus developing outskirts have to depend on other sources of water supply such as hand dug wells and boreholes. Kafanchan town in a similar note has wards such as Takau, Kaninkon and Maigizoh who were not part of the initial design of Kafanchan water board. Thus the need to assess the quality of underground water sources for drinking and other domestic uses in theses wards and those found in Kafanchan wards A and B become imperative. There are abundant literatures concerning water and its related problems. These individuals or groups approached the subject from diverse indicators or specific areas of interest such as Water Development, Ibbi and Nmadu (2012); Pollution, Edet et al. (2011); among other aspects. It will not be an exaggeration based on existing literatures to conclude that water contamination in cities, towns, villages and rural areas in Nigeria is a huge problem (Omaga, 2019). This problem is attested to from water analysis reported in the following studies.

Galadima et al., (2011) discovered that due to intensified uses of water homes, local markets abattoirs, oil, agricultural activities and the disposal of harmful wastes, heavy metal poisoning of domestic water has occurred among local communities in Nigeria.

Similar studies conducted by Dogo and Giwa (2014), indicate that solid wastes littered around drainages, road sides and homes have contaminated many sources of water supply in Kafanchan township. In a similar vein, studies conducted by Omaga (2019) on water quality index of Idemeriver in Okpokwu local government area, Benue state showed high degree of contamination and also the occurrence of waterborne disease causing bacteria and other microscopic organisms. Elsewhere in India, studies conducted on water quality using various parameters by Shiv Shanar et al., (2010); Verma et al., (2010) revealed high level of contamination and bacteria parasite that cause waterborne diseases. The big picture is that safe drinking water and adequate sanitation are crucial for the reduction of poverty, and crucial for sustainable development and social change (UNICEF, 2012). Conversely, investment in and access to potable water and sanitation services in developing countries like Nigeria is crucial to improving people's health, education, life expectancy and wellbeing, as well as bringing higher socio – economic benefits and development. It is also clear from the literatures that the challenges of sustainable clean drinking water are far from being over. Thus, this study provide a basis for other aspects such as heavy metal metals contamination and sewage seepage into shallow wells could provide a platform whereby sustainable clean water projects could be built upon.

STUDY AREA

Kafanchan is the headquarter of Jema'a Local Government Area in Kaduna State situated within Latitude 9°33'30'' to 9°36'30''N and Longitude 8°16'00'' to 8° 20' 00''E With an Elevation of 793m above sea level. The study area is located in tropical guinea savanna under Koppen's A_w type of climate with two distinct seasons, a wet summer and dry winter seasons. The major soil type is the tropical ferruginous soil which relates to the climate, vegetation, lithology and topography of the area (Abaje et al., 2009). The vegetation type found in this area is the guinea savanna. The relief is relatively flat and undulating and it influences the drainage pattern of the area. Rainfall occurs between the months of April to October with a single peak in August. The mean annual rainfall of the area is about 1800mm and the mean monthly temperature is 25℃, while the relative humidity is about 63% during the wet season (Abaje et al., 2009).

METHODOLOGY

Research Design

This research is analytical involving sample collection, sample preparation, laboratory analysis and result interpretation. Kafanchan town is made of five wards namely; Kafanchan A, Kafanchan B, Kaninkon, Maigizoh and Takau wards. This research employed a purposive random sampling method to collect data for this study. Purposive because samples were taken from each ward, and within each ward, samples were taken at random which has the power of offering every variable chance to be selected.

Data Collection Method

Data used for this study was obtained from both primary and secondary sources; data from the primary source are the water samples. On the site testing of the physical parameters (i.e. Temperature, Colour, Total Dissolve Solid, Electrical Conductivity, Turbidity and P^H) was conducted in line with established method of American Public Health Organization (APHA, 1995). A total of 15 samples were collected from the five wards in the following way; for each ward, 2 samples from hand dug well + 1 sample from borehole making a total of 3 samples per ward, were taken at random for the chemical properties test. Sample collection was done in the late hours of the day between 3.00 – 6.30pm in clean polythene bottles. Early in the morning, the samples were taken to Kaduna State Environmental Protection Agency (KEPA) laboratory for the physiochemical tests. Secondary data were obtained from journals, e – books, published and unpublished books on information on water quality standards and methods.

Techniques for Data Analysis

The parameters selected for testing the physiochemical properties of underground water for domestic uses in Kafanchan are presented in Table 1.

Table 1: Parameters Selected for Physiochemical Properties Testing.

s/no	Test	Parameters
1.	Physical	Temperature, Colour, Total Dissolve Solid, Electrical Conductivity, Turbidity and P^H
2.	Chemical	Chloride, Alkalinity, Hardness, Nitrate, Fluoride, Sulphate, Phosphorus, Iron and Magnesium

i. **Physical Test**: the first phase of the analysis was the test for the physical properties for the purpose of determining the quality of the underground water for domestic use. The temperature of the water samples were measured with standard mercury-in-glass thermometer. Also, on the sites, analysis of P^H, Colour, Total Dissolve Solid, Electrical Conductivity and Turbidity were done using calibrated HANNA multi parameter kit (model Hi 98130), Knick Portamass Conductivity meter, and the Turbidity meter (model 2100p HACH, Columbia, USA).

ii. **Chemical Test**: in the laboratory, test for Chloride, Alkalinity, Hardness, Nitrate, Fluoride, Sulphate, Phosphorus, Iron and Magnesium was conducted. The water samples were subjected to Atomic Absorption Spectrophotometer at the KEPA laboratory. The results obtained were recorded and analyzed using a One – sample T – test. More also, the mean, standard deviations, and standard Errorwere computed and tested at alpha level 0.05 for significance. SPSS version 23 was used for the ANOVA.

Table 2: **National Drinking Water Quality Standard (NDWQS), 2007.**

PARAMETER	P^H	Turbidity	Total Dissolved Solids	Nitrate	Chloride	Total Hardness	Fluoride	Iron	Manganese	Argon	Chromium	Lead	F. Coliform
NDWQS	6.5-8.4	5N TU	1500mg/l	24.0mg/l	200mg/l	1000	1.5mg/l	1.0mg/l	0.2	0.01	0.05	0.01	0

Source: NDWQS (2007).

RESULTS OF FINDINGS

The results obtained from the physiochemical analysis of underground water for domestic uses in Kafanchan are presented as follows;

Parameter	Color	Temp. □	PH	Conductivity (mV)	Total dissolved Solids (mg/l)	Nitrate (mg/l)	Turbidity (FAU)	Alkalinity (mg/l)	Cl (mg/l)	Hardness (mg/l)	Fluoride (mg/l)	Sulphate (mg/l)	Phosphate (mg/l)
WHO (2011)			6.5-8.4	1000	500	50	5	-	250	150	1.5	-	-
NDWQS (2007)			6.5-8.4	1000	500	50	5	-	250	150	1.5	-	-
Maigizoh ward													
1	colorless	22.10	6.83	72	100	9.6	10	11	48	1.04	1.2	ND	30.4
2	colorless	22.00	7.39	99	99	10.8	10	13	50	2.04	1.4	ND	38.9
3	colorless	21.80	7.35	80	105	6.5	9.2	45	45.3	2.05	1.3	ND	35.4
Kaf. A Ward													
4	colorless	22.00	6.74	90	125	4.3	10	28	34.6	1.23	1.1	ND	34.8
5	colorless	23.00	7.28	52	75	2.6	10	25	5.7	1.89	1.2	ND	38.4
6	colorless	22.20	7.38	67	96	5.4	9.8	26	45.6	1.90	1.5	ND	37.9
Kaf. B Ward													
7	colorless	22.10	6.5	72	145	1.6	10	36	23.4	1.04	1.2	ND	30.2
8	colorless	20.00	7.43	90	302	3.2	10	39	45.7	2.06	1.2	ND	38.9
9	colorless	22.00	7.38	52	178	5.8	9.9	32	35.2	2.07	1.3	ND	34.5
Takau Ward													
10	colorless	23.00	6.83	78	390	2.9	10	34	56.7	1.05	1.4	ND	30.1
11	colorless	21.00	7.29	78	98	3.9	10	47	21.4	1.05	0.9	ND	25.7
12	colorless	23.00	7.23	79	106	6.5	09	27	43.7	1.80	1.0	ND	36.6
Kaninkon Ward													
13	colorless	22.10	6.85	54	376	9.6	10	12	24.5	1.01	1.2	ND	30.6
14	colorless	22.00	7.31	70	96	7.7	09	14	53.2	2.01	1.4	ND	34.2
15	colorless	22.00	7.39	68	346	5.9	10	13	50.3	2.08	1.4	ND	38.9
Mean		22.02	6.94	73.4	175.8	5.75	9.793	25.13	38.89	1.62	1.25		32.24

Table 3: Results of Water Samples Analyzed for Physiochemical Parameters
Source: Laboratory Analysis, 2019.

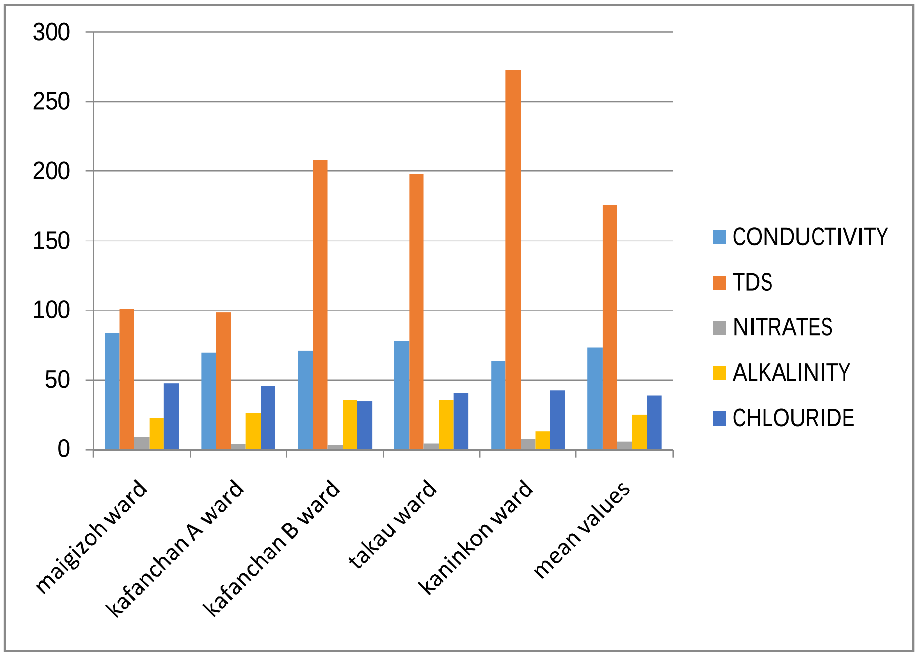
Results obtained from tests conducted on P^H, Colour, Total Dissolve Solid, Electrical Conductivity and Turbidity is presented in Table 3. The results shows that PH of water samples tested in Kafanchan ward A (6.74) and Kafanchan ward B (6.5) had the lowest P^H values compared to other wards tested but are within the WHO and NSDWQ permissible minimum values of 6.5 respectively.

Table 4: Mean Results of Water Samples Analyzed for Physiochemical Parameters

Parameter	Color	Temp. □	PH	Conductivity (mV)	Total dissolved Solids (mg/l)	Nitrate (mg/l)	Turbidity (FAU)	Alkalinity (mg/l)	Cl (mg/l)	Hardness (mg/l)	Fluoride (mg/l)	Sulphate (mg/l)	Phosphate (mg/l)
WHO (2011)	-	-	6.5-8.4	1000	500	50	5	-	250	150	1.5	-	-
NDWQS (2007)	-	-	6.5-8.4	1000	500	50	5	-	250	150	1.5	-	-
Maigizoh ward	Colorless	21.97	7.19	83.67	101.33	8.97	9.73	23	47.67	1.71	1.3	ND	34.9
Kaf. A Ward	Colorless	22.40	7.19	69.67	98.67	4.1	9.93	26.33	45.73	1.04	1.27	ND	37.03
Kaf. B Ward	Colorless	21.37	7.10	71.33	208.33	3.53	9.97	35.67	34.77	1.72	1.23	ND	34.53
Takau Ward	Colorless	22.33	7.12	78.33	198	4.43	9.67	36	40.6	1.3	1.1	ND	30.8
Kaninkon Ward	Colorless	22.03	7.18	64.00	272.67	7.73	9.67	13	42.67	1.7	1.33	ND	34.57
Mean		22.02	7.15	73.4	175.8	5.75	9.793	25.13	38.89	1.62	1.25		32.24

Source: Analysis of Laboratory Data, 2019.

Figure 1: Average Values of Some Parameters of Underground Water Samples in Study Area.



Source: Water Samples Analysis, 2019.

HYPOTHESIS TESTING

The analyses of mean results of findings are presented in the following Tables.

Table 5: One-Sample T-Test Statistics for Conductivity

One-Sample t-test Statistics for conductivity

	N	Mean	Std. Deviation	Std. Error Mean
Conductivity	6	73.4000	6.87511	2.80675

	Test Value					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Conductivity	26.151	5	.000	73.40000	66.1850	80.6150

The result of t –test in Table 5 shows that there was significant difference ($p < 0.05$) in Conductivity for the underground water sources between the 5 wards in Kafanchan.

Table 6:One-Sample t-Test Statistics for TDS (Total Dissolved Solids)

One-Sample t-test Statistics TDS

	N	Mean	Std. Deviation	Std. Error Mean		
Total Dissolved Solids	6	175.8000	66.97709	27.34328		
	Test Value					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Total Dissolved Solids	6.429	5	.001	175.80000	105.5119	246.0881

The result of t – test in Table 6 also shows that there was significant difference ($p < 0.05$) but at $p < 0.01$, there was no significant difference for the concentration of Total Dissolved Solids between the 5 wards. However the TDS is generally higher in all the mean samples compared to WHO and NDWQS standard.

Table 7:One-Sample T – Test Statistics for Nitrates

One-Sample t – Test Statistics for Nitrates

	N	Mean	Std. Deviation	Std. Error Mean		
Nitrates	6	5.7517	2.17633	.88848		
	Test Value					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Nitrates	6.474	5	.001	5.75167	3.4677	8.0356

The result of t – test in Table 7 also shows that there was significant difference ($p < 0.05$) but at $p < 0.01$, there was no significant difference for the concentration of Nitrates between the 5 wards.

Table 8:One-Sample t-Test Statistics for Alkalinity

One-Sample test Statistics for alkalinity

	N	Mean	Std. Deviation	Std. Error Mean
Alkalinity	6	26.5217	8.61095	3.51540

	Test Value					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Alkalinity	7.544	5	.001	26.52167	17.4850	35.5583

The result of t – test analysis in Table 8 also shows that there was significant difference ($p < 0.05$) but at $p < 0.01$ there was no significant difference for Alkalinity between the samples in the 5 wards.

DISCUSSION

The results obtained in Tables 4 and 5 showed that the P^H values are slightly acidic in samples 1, 4,7,10 and 13 while the rest are slightly basic. All observed values of TDS were much lower in concentration than WHO and NDWQS standard of 500 mg/l. Turbidity is mainly a function of the suspended materials in the water which ranges from colloidal to coarse dispersion. Turbidity values of 10 recorded in all the samples were higher than standard recommended value of 5 by WHO and NDWQS (FEPA 2011; NDWSQ 2007). The results obtained for Nitrates, Alkalinity, Chlorides, Fluorides, Iron, Sulphate, Phosphate and Hardness all falls below the minimum allowed levels of water quality requirement. The implication of the above findings is that water quality for drinking from these sources sampled (with the exception of turbidity) is not harmful for human consumption. Further to this, variation in values of physiochemical properties among the 5 wards examined could be as a result of variation in underlying regolith upon which the boreholes and wells were dug.

CONCLUSION

The study has presented data on physiochemical properties of underground sources of drinking water (Boreholes and Wells) in Kafanchan. The result showed that the values of all physiochemical parameters tested (with exception of Turbidity) fall below WHO and NDSWQ permissible minimum levels and hence suitable for drinking. However, turbid waters can be microbiologically contaminated and indirectly constitute a health issue. Further to this, higher levels of turbidity can protect microorganisms from the effects of disinfection, given rise to a significant chlorine demand and reducing the performance of some disinfection treatments like SODIS. Thus, turbidity could represent a key issue regarding the microbiological quality and disinfection of water which may require further investigation.

RECOMMENDATION

The study recommends that the causes and sources of high turbidity results be investigated and appropriate solution be provided by stakeholders in order to ensure safe underground drinking water sources in Kafanchan and environs with similar environmental characteristics.

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