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Assessment of the Physicochemical Quality of Well Water in Okene and Adavi Local Government Areas of Kogi State, Nigeria

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ABSTRACT
This study investigated the physicochemical properties of well water sources from Okene and Adavi Local Government Areas of Kogi State, Nigeria. Samples were collected during the dry and wet seasons from ten (10) sample locations within the study area using simple random sampling method. The wells were categorized by determining the type of well with respect to proximity of the wells to septic tank, presence of well casing with well cover, presence of animals/waste around the well and the topography of the well. Physicochemical parameters of the well water sources were assessed. Only 13% (5) of the wells surveyed conform to WHO standard with respect to the distance between the well and septic tank. The physicochemical properties were within permissible range as specified by WHO. Although, there were statistical differences in the mean values obtained between the sample locations with respect to some of the physicochemical parameters such as temperature (P-value 0.007), pH (P-value 0.045), turbidity (P-value 0.013), total suspended solids (P-value 0.001), chloride content (P-value 0.016), total dissolved solids (P-value 0.588), electrical conductivity (P-value 0.931) and total alkalinity (P-value 0.566). In conclusion, the study revealed that, hygienic practice around the wells in Okene and Adavi local government areas of Kogi State, Nigeria is poor and the siting of the wells were not in conformity with WHO standard. However, the physicochemical Parameters are relatively within the limits specified by WHO and NAFDAC. It was recommended that; the inhabitants of the study area should not consume well water without treatment. Also, going forward, wells should be constructed properly with cemented walls, well casing and situated far away from livestock and domestic animals, gutters, latrines, soak – away and other sources of contamination.

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INTRODUCTION

Water, which makes up almost 75% of the earth's surface, is the most important chemical component for all life forms on the planet (EL-Jakee *et al.,* 2009). However, just 2.5% of the total volume is fresh water, with the remaining 97.5% being saline water. 98.8% of the fresh water is inaccessible because it is frozen or too deep beneath. Humans can use just 1.2% of the fresh water on Earth (Hongeu *et al.,* 2013). However, a variety of variables and activities frequently jeopardize the quality and potability of this small amount that is naturally available for human use, thus limiting human availability (Bassem, 2013).

Water is sourced by most communities in Nigeria from streams, rivers, boreholes and wells (Shittu *et al.,* 2008). The safety of drinking water for the people of Okene-Adavi locality as in other parts of the state has been a major cause for concern. Majority of the population depend on well water sources for their water supply. However, the physico-chemical quality of well water sources in

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this locality has so far not been adequately assessed and reported. Potable water that is fit for human consumption deserves special attention because of its implication on public health and quality of life.

The World Health Organization believes that 80% of health issues in developing nations are related to water and sanitation. In many countries, including Nigeria, bacterial illnesses have been greatly exacerbated by contaminated water supplies (Ahmed *et al.,* 2013). In many places in Nigeria, including the local government districts of Okene and Adavi in Kogi state, there is a lack of recorded information on the prevalence rates of water-borne illnesses that are directly linked to well water.

There is an increasing demand for potable water and healthy food in Nigeria due to increased population (Upahi *et al.,* 2021) and the inadequacy of the supply especially in Okene and Adavi local Government areas makes it imperative that any available source is carefully protected and monitored. Therefore, this study is aimed at assessing the physicochemical quality of well water in Okene and Adavi local Government areas of Kogi state.

MATERIALS AND METHOD

Description of Study Area

The study area was Okene and Adavi Local Government Areas of Kogi State, Nigeria. Whereas, Okene local government area is located on the A^2 high way, upon the coordinates 7^0 33 N 6^0 14E with a land mass of 328km^2 and a population of 320,260, Adavi local government area is located on A^{123} highway upon 7^0 36 "05 "N 6^0'12' 01 "E with a land mass of 718km^2 and a population of 202, 194 according to 2006 population census. The sources of water for consumption in this locality include lake, reservoir, well and a handful of boreholes which are sparsely distributed. Majority of the population depend on well water as their main source of water for drinking, cooking and for other domestic activities. Ten sample locations were selected across the study area and they include: **Okene Local Government Area;** Okene Central, Obehira, Agassa, Okengwe Central, Ageva and **Adavi Local Government Area;** Nagazi, Ogaminana Central, Kabba Junction, Adavi Central, Irigony.

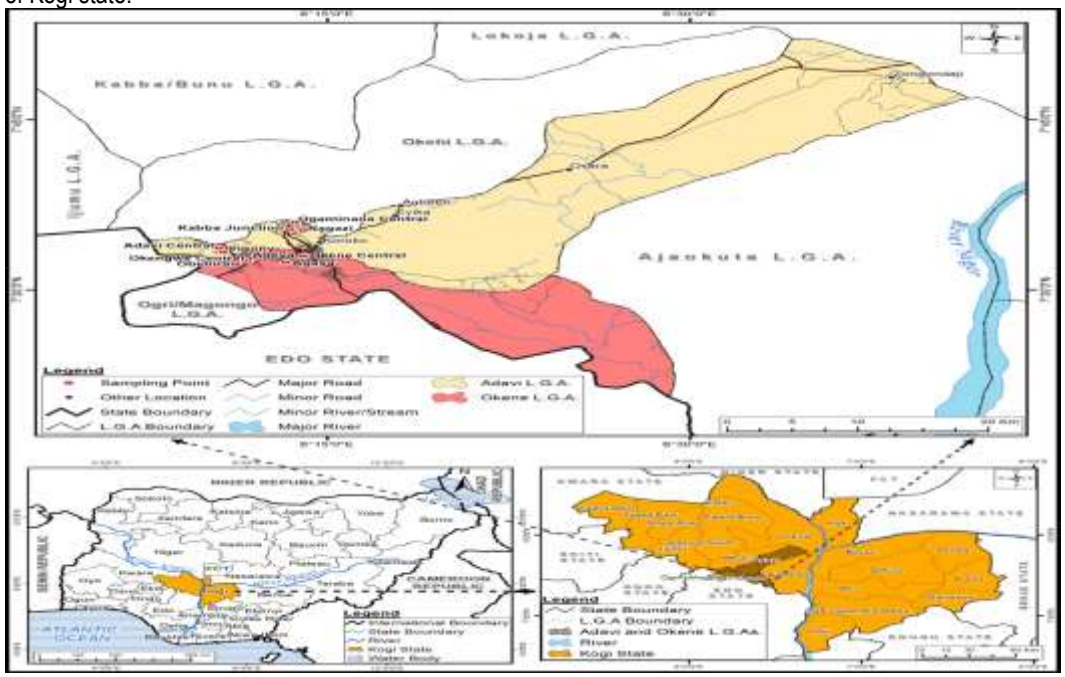

Figure 1: A Map Showimg Sampling Points in Adavi and Okene L. G. As of Kogi state

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Collection of Samples

Four (4) wells were sampled in triplicates from each of the ten (10) sample locations distributed across the two local governments that made up the study area. That is, a total of twenty (20) wells were sampled from each of the two local government areas making a total of forty wells sampled for this study. Equal number of samples (120 samples) was collected from the sample locations in both dry and wet seasons making a total of two hundred and forty (240) samples.

Water samples were collected aseptically in 500ml sterile bottles tied with a strong string to a piece of metal (500g) as the weight. The sterile bottle cap was removed and the weighted bottle lowered into the well to a depth of about 1-2 m. When no more air bobbles were seen, the filled bottle was brought to the surface and covered with the bottle cap aseptically. They were labelled and transported in ice packs to the laboratory for analysis (Aboh *et al*., 2015).

Categorization of Wells into Different Types

The distance between the well and septic tanks, topography of the well, presence or absence of animal dungs/ human faeces, presence of well casing, presence of well cover, whether the well is raised above the soil surface or not and the use to which the well is committed were determined. Distances were measured with the aid of a measuring tape while the other observation were done physically and through administration of questionnaire. (Olukosi *et al*., 2008)

Determination of Physicochemical Parameters

Physicochemical parameters such as Temperature, pH, Turbidity, Total Dissolved Solid, Total Suspended Solid, Total alkalinity, Electrical Conductivity and Chloride Content were determined using the guideline as provided in (APHA) American Public Health Association Manual "standard method for examination of water and waste water. The pH was measured instrumentally using pocket size pH meter Hanna instrument, the electrical conductivity using conductivity meter of model DDS 307, temperature with hand held thermometer, Total Dissolved Solid, Total Suspended Solid, Turbidity, Total Alkalinity and Chloride content were measured using appropriate Hanna Combo instrument (Aremu *et al.,* 2011)

Analysis of data

Results obtained were presented in tables. Post hoc analysis was also carried out using Turkey HSD with the aid of Graph Pad prism 8.0.2 scientific statistical package.

RESULTS

Well water types with respect to WHO standard in Okene and Adavi Local Government Areas of Kogi State

The form, structure and activities observed around the wells surveyed showed that 58% (23) of the wells had presence of faeces, animals and their waste around the well while 42% (17) had neither faeces, nor animal presence or their waste around the well. A total of 98% (39) had well casing while only 2% (1) had no casing. About 78% (31) had well cover while the remaining 22% (9) had no cover. Whereas, 91% (36) had their casing slightly raised above the ground with cover, the remaining 9% (4) were not raised above the ground level. Twenty-six percent (10) were on a higher topography compare to the location of the septic tank while the rest 74% (30) were either on the same plane ground or on a lower topography with respect to the location of the septic tank. Only thirteen percent (5) of the forty wells sampled were up to thirty metres (30M) away from septic tanks and therefore complied with World Health Organisation's Standard while the remaining 87% (35) fail to comply with the set standard by World Health Organisation shown in as shown Fig1

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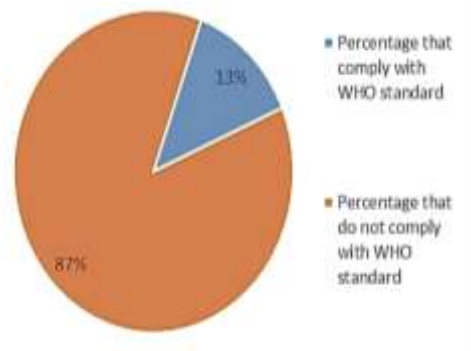

Figure 2: Percentage of Wells that Conform to WHO Standard
Key: WHO standard: Distance between the well and septic tank should be ≥30M

Physicochemical Parameters

Table 1 shows the mean values of the physicochemical parameters of well water samples from the ten sample locations as obtained during the dry season. It is evidently clear from the table that, there was no significant difference in the pH, temperature, turbidity and electrical conductivity of the well water samples collected from the different sample locations. However, whereas, pH, turbidity and electrical conductivity are within the limit specified by NAFDAC, the temperature values differ slightly as it exceeded the limit posited by NAFDAC.

There was significant difference observed in the total dissolved solid, total suspended solid, total alkalinity and chloride content but all were within the permissible limits of NAFDAC. However, sample from Nagazi location had a value 548.00±6.65mg/L for TDS which is higher than the permissible limit set by NAFDAC. Table 2 shows the mean values of the physicochemical parameters of well water samples from the ten sample locations as obtained during the wet season. The result reveal that, there were significant differences in the total dissolved solid of the well water samples from different sample locations. However, the values were within NAFDAC permissible limits.

There were no significant differences in the values obtained for Temperature, pH turbidity, electrical conductivity, total suspended solid, total alkalinity and chloride content. However, pH, electrical conductivity, total suspended solid, total alkalinity and chloride content were within NAFDAC permissible limits but temperature slightly exceeded the permissible limit while water samples collected from Ageva, Agasa, Okene central, Adavi central and Kabba junction area had mean values that exceeded NAFDAC permissible limits for turbidity.

Table 3 shows the effects of seasonal variation on the mean values of physicochemical parameters of well water from Okene and Adavi Local Government Areas of Kogi State. Whereas, there were no significant differences statistically in the electrical conductivity, total alkalinity and total dissolved solid between the two seasons, there was a marked significant difference in the total suspended solid, chloride content, turbidity, temperature and pH between the two seasons.

Table 1: Comparison of mean values of Physicochemical Parameters of Well Water in Okene and Adavi Local Government Areas of Kogi State during dry season

	Okengwe Central	Obehira	Agevа	Agasa	Okene Central	Irigony (Adavi)	Adavi central	Kabba Junction Area	Nagazi	Ogaminana Central
Temp (°c)	27.5±0.36a	26.25±0.18a	26.42±0.19a	26.58±0.15a	26.67±0.19a	27.00±0.12a	26.58±0.19a	26.58±0.19a	26.42±0.19a	26.25±0.13a
pH	7.4±0.10a	6.65±0.34a	6.77±0.09a	7.80±0.04a	7.34±0.14a	6.78±0.10a	7.04±0.09a	7.28±0.04a	7.55±0.07a	7.14±0.03a
Turbidity NTU	1.0±0.21a	0.71±0.49a	0.7±0.07a	0.63±0.14a	1.55±0.64a	0.38±0.05a	3.84±1.27a	0.55±0.07a	0.63±0.22a	1.08±0.55a

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	Okengwe Central	Obehira	Agevа	Agasa	Okene Central	Irigony (Adavi)	Adavi central	Kabba Junction Area	Nagazi	Ogamina na Central
Total Dissolved Solid	252.2±1.47f	524±1.22b	160.25±3.53h	427.75±1.80c	434.50±7.45c	270.58±7.58g	153.17±3.89h	340.17±5.49d	548.00±6.56a	341.83±6.82e
Electrical Conductivity	0.2925±0.05a	0.10±0.15a	0.18±0.03a	0.43±0.05a	0.57±0.06a	0.27±0.04a	0.23±0.02a	0.27±0.03a	1.33±0.61a	0.49±0.07a
Total Suspended Solid	10.97±0.46a	2.25±0.18b	2.5±0.36c	2.50±0.23c	4.08±0.15c	3.32±0.39c	3.17±0.58c	2.62±0.38c	2.25±0.13d	3.05±0.30c
Total Alkalinity	42.34±0.75b	27.17±7±0.30d	25.75±0.43d	37.92±0.97c	26.42±0.85e	26.42±0.38e	25.50±0.82e	24.67±0.91e	37.68±3.05c	45.08±0.62a
Chloride Content	30.33±0.10b	25.94±0.30b	16.15±0.84c	28.27±0.79b	15.63±0.67c	33.25±0.96b	14.83±0.71c	16.11±0.98c	43.58±0.98a	24.33±0.93c

WHO permissible limits; Tem≤ 40oC, pH≤ 8.5, Turb≤ 5NTU, TDS≤ 500mg/l, Electrical cond≤ 900, TSS≤ 30mg/l, Total Alk≤ 80, Chloride content ≤ 200mg/l

Table 2: Comparison of mean values of Physicochemical Parameters of Well Water in Okene and Adavi Local Government Areas ofKogi State During Wet Season.

	Okengwe Central	Obehira	Agevа	Agasa	Okene Central	Irigony (Adavi)	Adavi Central	Kabba Junction Area	Nagazi	Ogamina na central
Temp (ºC)	25.50±0.38a	28.17±0.47a	26.58±0.29a	27.58±0.15a	27.92±0.26a	28.33±0.53a	27.42±0.29a	27.92±0.23a	28.33±0.40a	27.75±0.28a
pH	6.72±0.11a	6.72±0.09a	6.83±0.14a	6.73±0.08a	7.23±0.13a	6.88±0.11a	6.87±0.04a	6.98±0.06a	7.08±0.08a	6.87±0.08a
Turbidity NTU	0.89±0.21a	0.96±0.17a	13.29±1.00a	8.03±2.63a	7.32±3.27a	1.78±0.70a	6.48±1.18a	8.63±0.66a	0.93±0.39a	1.24±0.12a
Total Dissolved Solid	456.17±56.02b	528.33±71.06a	257.92±36.63e	256.64±25.51e	407.42±21.17b	387.00±44.55c	299.58±23.37d	289.11±12.59d	438.50±28.18b	423.58±17.56d
Electrical Conductivity	0.64±0.08a	0.65±0.08a	0.39±0.05a	0.28±0.07a	0.47±0.08a	0.55±0.07a	0.38±0.04a	0.33±0.02a	0.73±0.06a	0.74±0.13a
Total Suspended Solid	21.67±0.94a	20.83±0.56a	21.83±0.84a	30.17±2.39a	21.67±0.89a	21.58±0.92a	27.56±2.44a	32.50±3.72a	28.33±2.97a	27.92±2.71a
Total Alkalinity	37.16±1.13a	28.75±1.39a	25.33±0.97a	21.67±1.67a	36.56±3.35a	42.33±3.82a	17.75±0.95a	28.75±1.86a	32.92±1.44a	27.50±1.69a
Chloride Content	25.94±0.95a	18.13±0.93a	11.74±1.82a	9.50±0.98a	8.77±1.48a	11.39±0.73a	20.53±2.37a	19.84±2.11a	14.76±2.00a	16.34±1.0a

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Table 3: Effects of Seasonal variation on the mean values of the Physicochemical Parameters of well water in Okene and Adavi Local Government Areas of Kogi State.

Physiochemical parameters	Season	Values (Wells)
Temperature	Dry	26.63±0.12
	Wet	27.55±0.28
	p-value	0.007*
Ph	Dry	7.17±0.12
	Wet	6.89±0.05
	p-value	0.045*
Turbidity	Dry	1.11±0.32
	Wet	4.95±1.37
	p-value	0.013*
Total Dissolved solids	Dry	345.2±43.87
	Wet	374.4±29.53
	p-value	0.588**
Electrical conductivity	Dry	0.51±0.12
	Wet	0.52±0.05
	p-value	0.931**
Total suspended solid	Dry	3.67±0.83
	Wet	25.41±1.37
	p-value	0.001*
Total alkalinity	Dry	31.89±2.51
	Wet	29.87±2.37
	p-value	0.566**
Chloride Content	Dry	24.84±2.96
	Wet	15.69±1.74
	p-value	0.016*

Keys: * means significant at P≤0.05 ** means not significant
WHO permissible limits; Tem≤ 40oC, pH≤ 8.5, Turb≤ 5NTU, TDS≤ 500mg/l, Electrical cond≤ 900, TSS≤ 30mg/l, Total Alk≤ 80, Chloride content ≤ 200mg/l

DISCUSSION

Well types with respect to WHO standard

The form, structure, topography and activities around the wells, could have a great impact on the bacteriological quality of the wells and constitute a great health risk to the populace. Only 13% (5) of the well surveyed complied with WHO standard. World Health Organisation's standard states that, a well should be at least 30 m away from septic pit, latrine or soak – away.

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87% (35) did not meet this standard. It has been reported that latrines and soak away are great sources of contamination to ground water due to seepage and leakages (Olukosi, *et al.,* 2008).

Though, a good percentage of the wells 39 (98%) had well casing, there were however cracks observed in 70% (27) during the survey. These cracks may have aided exchange of contents between most of the wells and septic tanks, since 87% of the well share good proximity to the location of the septic tank. Again 78% (31) had well cover but about 50% (19) of these well covers were either rusted or had openings into the well. Contamination of the well could have been possible through these observed openings on the covers of the well.

Ninety-five percent (95%) of the wells surveyed were used as drinking water source. Other uses includes but not limited to bathing, washing of clothes, kitchen utensils and ablution. Only about 5% of the people treat the water by boiling it before drinking. It is imperative to note that, besides drinking of contaminated water, disease can be contracted through the use of contaminated water for washing fruits, vegetables, cooking and eating utensils (Stewart-Koster *et al*., 2024).

Physicochemical Parameters of the Wells

The Temperature of all the sampled wells from the ten sample locations that make up the two local government areas were within WHO prescribed limit but slightly higher than the limit prescribed by NAFDAC. From the analysis, the temperature has a mean and a coefficient of variation of 26.63^{o}C and 0.12 for dry season as against a mean and coefficient of variation 27.55^{o}C and 0.28 for wet season. This shows that the temperature of the well water is higher in wet season than in dry season. It is not unconnected with the ambient temperature of the environment. This finding disagrees with the work of Singh *et al*., (2024) where they discovered that the mean and coefficient off variation of temperature for well water is higher in dry season than in wet season. The finding however agrees with the work of Aremu *et al.,* (2011), Ibrahim and Ajibade, (2012) on the ground that the values of temperature for well water are within the prescribed limit of WHO guideline.

PH, Total Alkalinity, Total Suspended Solid, Chloride Content and Electrical conductivity were within the limits specified by NAFDAC and WHO standard. This agrees with the findings of Aremu *et al*. (2011) where he reported that the mean values for PH, Total Alkalinity, Total Suspended Solid, Chloride Content and Electrical Conductivity of well water align with the range and they fall within the limit prescribed by World Health Organisation's standard.

Turbidity for all the ten sample locations were within limit during the dry season but about five locations (50%) namely, Ageva (13.23NTU), Agasa (8.03 NTU), Okene Central (7.32 NTU), Adavi Central (6.48 NTU) and Kabba Junction Area (8.63 NTU) showed values of turbidity higher than the permissible limits WHO standard (5NTU) (WHO, 2008) during the wet season. This high turbidity during wet season may have been due to run off of both organic and inorganic particulate matter into the wells during rainy season. This agrees with the findings of Ibrahim and Aibade (2012) and Singh *et al.,* (2024) where they discovered that 60% and 75% of their respective well sample sites had turbidity values higher than the permissible limits prescribed by both NAFDAC and WHO. High turbidity could prevent microorganisms from the effect of disinfection and aid bacterial proliferation.

Mean values for total dissolved solid for wells from the ten sample locations are within range and comply with the limits permissible by NAFDAC. However, Obehira sample site had Total Dissolved Solid mean value of 524±1.22mg/l in dry season and 528.33±71.06mg/l in wet season which are higher than the permissible limit of 500mg/l. this finding agrees with the value reported by Aremu *et al.* (2011) where a high TDS mean value of 1048.67mg/l was observed. This may have been due to differences in organic matter that remain as residue in the wells.

In conclusion, the study revealed that, hygienic practice around the wells in Okene and Adavi local government areas of Kogi State, Nigeria is poor and the siting of the wells were not in conformity with WHO standard. However, the

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physicochemical Parameters are relatively within the limits specified by WHO and NAFDAC. It was recommended that; the inhabitants of the study area should not consume well water without proper treatment such as boiling at 100°C. Also, there may be need to close some wells especially those that are very close to septic tank with cracked or no well casing. Wells should be constructed properly with cemented walls, well casing and situated far away from livestock and domestic animals, gutters, latrines, soak – away and other sources of contamination.

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