ASSESSMENT OF UNDERGROUND WATER QUALITY AND ITS SUITABILITY FOR IRRIGATION AND CONSUMPTION PURPOSE IN FEDERAL COLLEGE OF FORESTRY JOS, NIGERIA

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ABSTRACT Water is an essential natural resource for sustaining life and environment. Several activities have led to pollution of ground water. This study assesses the underground water quality level and its suitability for irrigation and drinking purpose. Water samples were collected in four locations in the Federal College of Forestry as follows: Display garden well, College back gate well, borehole and poultry well. The samples were analyzed at the Bauchi State water quality Laboratory for irrigation and drinking purpose. The results of the analysis was compared to NESREA (2011) and NSDWQ (2015) standards. Nitrate level ranged from 0.38-7.40Mg/l and was found to be high for drinking purpose. Phosphate ranged 0.04-30.8mg/l, while Potassium 4.5-78mg/l, both were high for irrigation and consumption purpose. Excess level of nitrate can cause blue baby disease. Excessive consumption of phosphate leads to a higher mortality in patients with renal disease, which is also associated with increased prevalence of cardiovascular diseases in the general population. It was found from this research that underground water at 5m and beyond is not suitable for drinking, Phosphate and Potassium level should be within recommended standard before it can be used for irrigation purposes.

KEYWORDS Irrigation, underground water, Phosphate, potassium, water quality, cardiovascular diseases, irrigation and consumption purpose.

Introduction

The increasing need of water for crop production for the growing population is causing rapid expansion of irrigation throughout the world. Water being a limited resource, its management in the most efficient possible way, is basic to survival of the increasing population (Javier *et al.*, 2017). Water covers about 70% of earth's surface and is essential for life. Water has a number of unique chemical and physical properties that makes it essential for usage (Adogun *et al.*, 2011; Javier *et al.*, 2017).

Agriculture accounts for about 70% of water withdrawals worldwide, increasing to over 90% in developing countries. Water is important to humans and agriculture; it is necessary for the production of our food, natural fiber of our clothing, bio-fuels and other goods based on agricultural raw materials (Kymar, 2006). There are different sources of water which are surface and ground water, for irrigation purposes. Water from these sources may be conveyed by gravity or pressurized pump, and is further led to the field through an appropriate conveyance infrastructure. Ground water is the sustaining supply for surface water and arid areas, surface water often enters and returns to the ground water system through sink holes and cave openings (Koffi *et al.*,2017).

Ground water is defined as water occurring within the sub-surface geological environment; it includes all water that occurs below the earth's surface occupying voids of previous rocks and soil. Groundwater is derived principally from precipitation that falls upon the earth surface and percolates downward under gravity. Underground water is generally the cheapest to replace, since it does not need the extensive pipeline and treatment facilities required for surface supplies, unlike surface water which flows indefinite supply and limited channels (Xu *et al.*,2019).

Ground water contained in shallow underground aquifers has played significant role in developing and diversifying agricultural production. When ground water is accessible, it offers a primary buffer against the unpredicted occurrence of some climatic condition. Ground water occurs in the pore spaces within rocks and alluvium, in solution opening or conduits in areas underlain by soluble carbonate rocks (Xu *et al.*,2019).

The natural chemistry of the ground water is largely controlled by the dissolution of the geologic materials through which the water flows. Contaminant enters through chemical composition. Ground water is also affected by several other storage reservoirs and canals. Contamination of water bodies has increasingly become an issue of serious environmental concern. Clean water is a priceless and limited resource that man has begun to treasure only recently, after decades of pollution and waste (Water and WHO,2004; Adamu *et al.,* 2015). Potable water is a very important component for good health and the socio-economic development of man; but it is lacking in many dissolved substances (Adamu *et al.,* 2015). Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have polluted water supplies as a result of inadequate treatment and disposal of water from humans and livestock, industrial discharges and over use of limited water resources.

The major sources of pollution to streams, rivers, underground and ground water arises from anthropogenic activities that is largely caused by the poor and uncultured living habit of people, as well as the unhealthy practices of factories, industries and corporate bodies. Ground water pollution could be avoided when boreholes and wells are located far from any sources of potential pollution. Monitoring the quality of water is very essential for environment safety (WHO, 2009). Water quality analysis is one of the most vital aspect of ground water studies. Hydro-chemical study reveals that chemical analyses form the basis of interpretation of the quality of water in relation to source, geology, climate and use (Fatoke *et al.*, 2011). The natural groundwater analyses for physical and chemical properties including trace elements contents are very important for public health studies, little wonder this research was dedicated for this purpose (Kot, 2009).

Season is a major factor that affects water quality, making water to become highly concentrated with dissolved heavy metals during dry season, which is hazardous to both plants and human health (Duncan *et al.*, 2018). Water for irrigation and drinking purposes is expected to be fresh, but with the absence of available fresh surface water, most Nigerians have resorted to the use of ground water, especially in Jos North Local Government Area, where the study area is located, the residence usually use the underground water for domestic and irrigation purposes; hence, the available ground water needs to be assessed to avoid adverse effect on plants, animals as well as human beings within the study area.

This study was designed to characterize the extent and nature of concentration of elements that forms the physicochemical properties of ground water, to ascertain if it is within the permissible limit that is set as standard for irrigation and drinking purpose (Zhang *et al.*, 2011). Therefore, evaluating the ground water quality within the study area is very pivotal to the wellbeing of plants, animals and Humans. Therefore, the objective of this study was to assess underground water quality and its suitability for irrigation and consumption purpose in Federal college of Forestry, Jos, Nigeria.

Study Area Description

The study was carried out in Federal College of Forestry Jos, Jos-North Local Government Area of Plateau State. Jos is located on latitudes 9º 45'N and longitude 8º 54'E on an altitude of about 180 metres above sea level. The area lies within the Southern Guinea Savannah ecological zone. The mean rainfall for the area is about 1250mm and a mean temperature of 35.5ºCThe climate of the state is cool due to its high altitude. Rainy season is usually between April and September, while the dry season is from October to March. The mean annual rainfall is 1,260mm (Oiganji *et al.*, 2019).

Sampling of Water

Samples were collected within eight weeks' interval starting from the month of October to February (12^{th} of October 2017 to $12^{th}$of February 2018), usually at 8:00am during the stated period. A container with a rope was used to collect the sample. The container was thoroughly cleaned by rinsing it with 8N, HNO_3 and de-ionized water to ensure uncontaminated samples as recommended by Seshananda *et al.*, (2016). It was then put into a high density PVC bottle which was kept air tight and labeled property for identification; aeration during sampling process was avoided by quick corking of the bottles and transported quickly to Bauchi State Water Board and water quality laboratory.

A total of 40 samples was collected, ten (10) samples from each of the three (3) wells and ten (10) samples from the tap in the study area. The four locations were: Display garden well with an elevation of 1147m, latitude N 09º56.8191and E 008º 53.5191,College back gate well with elevation 1165m, latitude N 09º 56.6861 and E 008º 53.6631, borehole with an elevation of 1166m, latitude N 09º 56.8391 and E 008º 53.6041, poultry well with elevation 1170m, latitude N 09º 56.9241 and E 008º 53.6781. The height of the water table at the instance the water samples were collected are presented in Table 1.

Table 1: Different depths (m) at which samples were collected within the study period

Location/depth	12/10/2017	12/12/2017	12/02/2018
Poultry well	3.27	6.80	5.26
Back gate well	3.04	4.01	5.98
Display garden well	2.76	3.10	2.93

Chemical Analysis

The chemical analysis of water involves the chemical tests which were carried out to detect some chemical parameter as well as the relative chemical characteristics of the water. The chemical test were: total dissolve solids, total hardness (TH), pH, electrical conductivity, chlorine, nitrate, phosphate and potassium (Oiganji and Dikam, 2020)

Water Sampling Analysis

The water samples were analysed for chemical characteristics for irrigation and drinking purpose. Standards methods and procedures explained by the national environmental standard and regulation enforcement agency, was used to analyze the parameters (NESREA, 2011; Boniface *et al.*, 2016). The parameters that were analyzed, unit and process are stated in Table 2.

Table 2: Parameters Unit and Methods Assessed

Parameters	Unit	Method that was Used
pH	pH	pH meter
Electrical conductivity	µs/cm	Conductivity meter
Total hardness	Mg/l	EDTA titrimetric
Potassium	Mg/l	Photometer
Total dissolve salt	Mg/l	Conductivity meter
Sulphate	Mg/l	Sulfa Ver 4
Calcium	Mg/l	EDTA titrimetric
Nitrate	Mg/l	Spectrophotometric
phosphate	Mg/l	Spectrophotometric
Chloride	Mg/l	Argentometric

Statistical Analysis

Data obtained were analyzed using prism windows version 7.04. Analysis of variance (ANOVA) was conducted to test for significant differences between means. Means that were significantly different were separated using the least significant difference (LSD) as provided (Omotosho, 2018).

Result and Discussion

Chemical Parameters

Table 3 – 5 Shows the chemical parameters of the analyzed sample of water collected at the four different locations within federal college of forestry, Jos.

Table 3: Concentrations of elements in water samples collected in the month of October

Parameters	Unit	Borehole	Display garden	Collegeback gate well	Poultry well	NESREA (2011)	NSDWQ (2015)
pH		7.42	1.18	5.76	6.95	6.5-8.5	6.5-8.5
EC	µ scm^{-1}	145	189	121	444	0-1000	1000
TDS	Mg/l	72.9	94.8	61.0	220	500	500
TH	Mg/l	25.0	34.0	18.0	75.0	150	100
Nitrate	Mg/l	0.38	7.40	6.60	2.40	10	0.2
Sulphate	Mg/l	26.0	13.0	15.0	11.0	500	400
Phosphate	Mg/l	2.20	5.40	29.7	9.50	0.5	0.1
Potassium	Mg/l	3.90	3.70	2.70	3.10	50	0

*NESREA (National Environmental Standard and Requirement Enforcement Agency) and NSDWQ (Nigerian Standard for Drinking Water Quality)

pH

p^H is the measure of acidity and alkaline level in the water. The p^H obtained in the month of October ranged from 5.76 -7.42, the highest pH valve of 7.42 was obtained at borehole water behind the copper's lodge, while the lowest pH value of 5.76 was obtained at the well at the back gate of the college. The values obtained at the different four locations on the 12th of October, 2017 were within the acceptable limit according to NESREA (National Environmental Standard and Requirement Enforcement Agency) and NSDWQ (Nigerian Standard for Drinking Water Quality) as indicated in Table 3.

Most plants grow well when the media solution pH is 5.6 to 6.2, a pH value above 8.5 may cause iron, manganese and other minor nutrients to become unavailable to plants leading to deficiencies, p^H in the soil control nutrient availability because low p^H may be responsible for excess iron and manganese deficiencies. The concentration of the p^H value in the study area were or within the recommended limit for irrigation and domestic water by NESREA and NSDWQ as shown in Table 3.

The p^H values obtained during the second samples collection which was on the 12th of December, 2017 ranged from 6.74-7.61. The highest pH value of 7.61 was obtained from poultry well, while the lowest pH value of 6.74 was observed from displaying garden well, after considering the four different locations as presented in Table 4.

Table 4: Chemical parameters of the analyzed sample of water collected on the 12th of December

Parameters	Unit	Borehole	Display garden well	College back gate well	Poultry well	NESREA (2011)	NSDWQ (2015)
pH		7.42	6.74	6.86	7.61	6.5-8.5	6.5-8.5
EC	µ scm^{-1}	129.1	218	156	457	0-1000	1000
TDS	mg/l	63.3	112	74.8	233	500	500
TH	Mg/l	40.0	30.0	22.0	120	150	100
Nitrate	Mg/l	3.60	0.74	2.12	1.80	10	0.2
Sulphate	Mg/l	4.00	10.0	4.00	7.00	500	400
Phosphate	Mg/l	0.21	0.53	1.10	0.76	0.5	0.1
Potassium	Mg/l	5.30	3.60	1.80	4.70	50	0
Chlorine	Mg/l	6.80	1.60	nill	2.50	350	250

*NESREA (National Environmental Standard and Requirement Enforcement Agency) and NSDWQ (Nigerian Standard for Drinking Water Quality)

The concentration of the p^H value in the study area were within the recommended limit except the sample obtained from the college back gate well which is above the acceptable limit by NESREA and NSDWQ both for irrigation and drinking purpose as indicated in Table 4

The pH values obtained during the third samples collection on the 12th of February, 2018 ranged from 7.23-12.62 which is significantly different from the concentration pH level obtained on the 12th October and 12th December 2017. The maximum p^H value of 12.62 was obtained from the college back gate well water sample, while the minimum pH value of 7.23 was observed from borehole water after the four different locations were being considered. The results of this study agree with that obtained by Esmaeil *et al.,* (2020) and Ibrahim *et al.,* (2015) because the P^H reported here is of same range.

Table 5: Chemical parameters of the analyzed samples of water that was collected in the month of February

Parameters	Unit	Borehole	Display garden well	College back well	Poultry well	NESREA (2011)	NSDWQ (2015)
PH		7.23	7.36	12.6	8.11	6.5-8.5	6.5-8.5
EC	µ scm^{-1}	104	371.0	278	52.2	0.1000	1000
TDS	Mg/l	51.9	186.0	136	262	500	1000
TH	Mg/l	28.0	60.0	40.0	105	150	100
Nitrate	Mg/l	2.20	1.84	8.72	1.76	10	0.2
Sulphate	Mg/l	17.0	4.00	19.0	12.0	500	400
phosphate	Mg/l	0.09	0.04	30.8	0.08	0.5	0.1
Potassium	Mg/l	33.0	78.0	4.50	46.0	50	0
Chlorine	Mg/l	2.50	6.80	nill	1.60	350	250

*NESREA (National Environmental Standard and Requirement Enforcement Agency) and NSDWQ (Nigerian Standard for Drinking Water Quality)

Electrical Conductivity (EC)

The electrical conductivity obtained 121.3 -444.0µscm-1, the highest electrical conductivity value of 444.0µ scm-1was obtained at poultry well, while the lowest electrical conductivity value of 121.3µ scm-1 was obtained from the well at the back gate of the college from the first samples taken on the 12th of October, 2017. The values obtained at the four different locations were within the acceptable range according to NESREA and NSDWQ as indicated in Table 3.

Electrical conductivity concentration value was within the recommended limit for both irrigation and domestic use by NESREA and NSDWQ as shown in Table 3.

Table 4 shows that the electrical conductivity level observed when samples were collected on the12th December, 2017, the EC ranged from 129.1-457.0 µScm-1; the maximum electrical conductivity value of 4.57.0 was obtained at poultry well, while the minimum electrical conductivity value of 129.1 was observed from the water sample gotten from the borehole, furthermore, when samples were collected in the month of Febuary, 2017, the EC obtained ranged from 52.2-371.0; the maximum EC value of 371.0 was obtained from the display garden , while the minimum EC of 52.2 was observed from poultry well.

The values obtained at the four different locations were below the recommended range by NESREA and NSDWQ, which makes the water samples all suitable for both irrigation and drinking. The results obtained in this research are at par with what Esmaeil *et al.,* (2020) and Ibrahim *et al.,* (2015) reported.

Total Dissolve Solids

Total dissolve solids refer to the total amount of concentrates dissolved in the water that causes drastic reduction in water quality. The total dissolve solids obtained ranged from 61.0-220.0Mg/l, the highest total dissolve solids value of 220.0 was obtained from the poultry well water, while the lowest total dissolve solids value of 61.0 was obtained from the well at the college back gate when the first samples taken on the 12th of October, 2017. The values derived at the four different locations were within the recommended range according to NESEA and NSDWQ for the month of October as indicated in Table 3.

Two months later when samples were collected, TDS ranged from 63.3-233.0 mg/l, the maximum total dissolve solids value of 233mg/l was obtained at from the poultry well, while the minimum total dissolve solids value of 63.3 was observed from the borehole water. The values obtained were within the permissible range by NESREA and NSDWQ as indicated in Table 4 both for irrigation and drinking purpose.

The values obtained at the four locations were all within the acceptable range by NESREA and NSDWQ as indicated in the Table 5 for both irrigation and drinking purpose for the month of February.

Total Hardness

Total hardness is a measure of the amount of hard metals that are present in the water that hinders water from lather. The Total hardness (TH) obtained on the 12th of October 2017; ranged from 18.0-75.0Mg/l, the highest total hardness value of 75.0 was obtained from the poultry well, water, while the minimum total hardness value of 18.0 was obtained from the well at the college back gate. The values obtained at the four different locations were within the recommended range according to NESREA and NSDWQ as indicated in Table 3, the same pattern was observed when water samples were collected in the month of December, 2017 as shown in Table 4.

The total hardness obtained during the third time of sample collection on the 12th of February 2018, ranged from 28-105Mg/l, the minimum TH value of 28mg/l TH was obtained from borehole, while the maximum concentration level of 105mg/l also observed from poultry well water for suitability in irrigation operation and drinking. The values obtained at the four different locations falls within the acceptable range for irrigation according to NESREA but above the acceptable limit according to NSDWQ which makes it unsuitable for drinking purpose as indicated in Table 5. TH was not within the acceptable range in the month of Febuary indicating that the well water is very hard, which may probably be related to the availability of some essential nutrients like calcium, sulphate and bicarbonates. The hardness of water prevents formation of sufficient lather with soap.

Nitrate

Nitrate is the level of nitrogen in water, its presence is required for biological reaction to proceed which exists in four main forms, in the form of protein, amino acids, urea and ammonium salts. The Nitrate obtained during the first samples collection on the 12th of October, 2017 ranged from 0.38-7.40Mg/l. The values obtained at the four different locations were all within the acceptable range according to NESREA for irrigation purpose but none was within the acceptable range according to NSDWQ for human consumption as indicated in Table 5. Excess level of nitrate which is one of the most common ground water contaminants can cause methemoglobinemia, or blue baby disease.

Sulphate

Sulphate is the level of Sulphur in water, its presence in a very high level may cause water to be unpleasant to drink. The Sulphate values obtained during the first samples collection which was in the 12th October 2017. The value varies between 4.0-26.0Mg/l, the maximum Sulphate value of 26.0 was obtained from the poultry well water. The values obtained at the four different locations were within the acceptable range according to NESREA and NSDWQ for both irrigation and domestic use as shown in Table 3-5.

The values obtained are related to that of Ibrahim *et al*.,(2015) with sulphate values ranged between 33.1 - 81.3 with the mean value of 57.5 mg/L, Esmaeil *et al.,* (2020) obtained 0.08 – 22.13 in their study area, the result of this study agrees with the standard results and those in literature.

Phosphate

Phosphate is the level or degree of phosphorus as an element in the water. The phosphate values obtained ranged from 0.04-30.8mg/l. All the values obtained at the four separate areas were not within the acceptable range and standard range according to NESREA and NSDWQ as presented in Table 3-5.

Excessive consumption of phosphate is harmful to health, which leads to a higher mortality in patients with renal disease. It is entirely absorbed in the gastrointestinal tract and research has demonstrated that individuals with renal disease have significantly elevated concentrations of phosphate levels. It also seems to damage blood vessels and induce aging process. It is also associated with increased prevalence of cardiovascular diseases in the general population (Esmaeil *et al.*, 2020).

Potassium

Potassium is often present in significant amount in irrigation waters, as an-essential nutrient which acts favorably in reducing the harmful effect of saline water on crop growth. All the values obtained at the four different locations were all within the acceptable range according to NESREA standard for irrigation, while the measured values were not within the acceptable range according to NSDWQ for human consumption as shown in Table 3.-5.Potassium can cause health problems when a person consumes more than the recommended level. Individuals with good kidney function can efficiently rid the body of excess amounts of potassium in the urine.

Chlorine

High concentrations of chloride can make water unpalatable and therefore unfit for drinking or livestock watering. Most chlorine occurs as chloride (Cl-) in solution. It enters surface water with the atmospheric deposition of oceanic aerosols, from industrial and sewage affluent and agricultural and road runoff. All the values obtained at the three different locations were all within the recommended range. According to NESREA and NSDWQ for both irrigation and consumption as indicated in Table 3.-5. Ibrahim *et al.,* (2015) reported a range 0.64 to 1.36 mg/L which is at par with results obtained in this research.

Conclusion

The results showed that parameters considered are in compliance with NESREA and NSDWQ standards, if the ground water is to be used for irrigation purposes. However, all the sources with ground water depth at 3-5m are not suitable for drinking, due to the excess level of Nitrate, Phosphorus and potassium.

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