Asian Soil Research Journal

3(2): 41-51, 2020; Article no.ASRJ.56392
ISSN: 2582-3973

Quantitative and Qualitative Soil Water Resources Potentials and Soil Assessment of River Onyongo Drainage Basin for Agricultural Use-Oju Local Government Area - Benue State, Nigeria

Garpiya Bodinga Timothy[1*], Aminu Ali[2] and Kyat Mcgyotwowa Makama[2]

[1]Department of Agronomy, Faculty of Agriculture, Taraba State University, Jalingo, Nigeria.
[2]Department of Soil Science, College of Agronomy, Federal University of Agriculture, Makurdi, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author GBT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AA is the instructional authority who oversees the research work at all stages and author KMM managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ASRJ/2020/v3i230071
Editor(s):
(1) Dr. Alessandro Buccolieri, Università del Salento, Italy.
Reviewers:
(1) Nitin Mishra, Graphic Era University, India.
(2) Islam-ul-Haque, Eco-Steps, Pakistan.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56392

Original Research Article

Received 27 February 2020
Accepted 02 May 2020
Published 02 June 2020

ABSTRACT

To assess the quality of River Onyongo catchment area for agricultural purposes. Field and laboratory assessment was carried out.

Water resources potential assessment was carried out in part of River Onyongo catchments area. The topographical map was used to carve out the study area. Geological mapping of the study was carried out by compass. Field permeameter pits were established in four locations within the study area to determine the coefficient of permeability of sub-surface soils/lithology by Darcy Law. Depth to water table was measured in some selected hand-dug wells. Discharge measurement of River Onyongo rainy season was 199,888.12 litres/second and 2,770.62 litres/second in dry seasons while River Ichow (bridge) had 354.3 litres/second in the rainy season and 195.43 litres/second at

**Corresponding author: E-mail: bodingagarpiya@gmail.com;*

the upstream; there was no flow during the dry season. Water samples were collected in the various locations in the study area and analysed in the laboratory. The relief of the study ranges from 100 m to 223 m above mean sea level. The Sodium Absorption Ratio (SAR) of the water sample ranged from 0 – 10 mg/l indicating that water can be used on all crops and all soils. The coefficient permeability/lithology of the study area ranged from 0.36 – 29.5 m/day corresponding to fine-grained sand to medium-grained sand – coarse-grained sand. Recommendations for the use of water for optimal agricultural purposes and production in the study areas were made.

Keywords: Water resources potentials; sub-surface soil/lithology; discharge measurement; coefficient of permeability; sodium adsorption ratio; River Onyongo.

1. INTRODUCTION

1.1 Background

The quality of water required for enhancing agriculture production and crops yields in most of the regions of the country is becoming scarce and insufficient. Surface water quality is deteriorating and groundwater is being polluted and irreversibly damaged by the intrusion of saltwater along the coastal zones. Poor water control also contributes to erosion especially in hilly and highland regions is experiencing massive deforestation due to logging and agricultural expansion to soil nutrient leaching in wetter areas [1]. Investment in water control thus becomes very important, whether, through conventional irrigation or natural water resources management practices to facilitate water harvesting, drainage or diversion as the case may be. According to 20, improvement in water management is key to increased cropping intensity in the rainfed system of agriculture [2].

The Nigerian Meteorological Agency yearly produces the Seasonal Rainfall Prediction (SRP) and the monthly Drought Flood Monitoring (DFM) Bulletin. Both products provide critical information on water and moisture availability during the year and are therefore keys for the planning of socio-economic activities in all rainfall-sensitive sectors of the economy. The main input data in the production of the SRP is rainfall, otherwise referred to as water and or moisture availability for agriculture, water management, health and other sectors [3].

It is therefore important that the natural resources (soil and water) of the various agro-ecological zones be properly managed based on scientific and systematic approaches, which include: surface and groundwater monitoring. The water resources potentials of Oju LGA Benue State (known for agricultural production) have not been adequately evaluated.

2. LITERATURE REVIEW

The water resources of Nigeria are enormous and unevenly distributed among the various hydrological areas. The Niger Delta and tropical rainforest areas have the highest precipitation of about 3000 mm/year and longer duration of rainfall up to eight months. This is followed by the Savanna zone with 1000 -1500 mm/year rainfall, the amount of rainfall decreasing northwards. The Sahel has annual precipitation of less than 750 mm/year and may be as low as 500 mm/year in the northeastern region occasionally [4].

Agriculture is the mainstay of the economy in Oju LGA of Benue State, engaging over 75% of the population. Benue state boasts of one of the longest stretches of river systems in the country with great potential for a viable fishing industry, dry season farming through irrigation and for an inland water way. The waters are excellent for recreational purposes, boating and swimming. There are masses of unusually tall trees in the deep valleys and on the pretty steep highlands, which are all however inhabited [5].

3. STUDY OBJECTIVES

The study objectives are as under;

1. To Evaluate the quality of the surface and underground water of part of River Onyongo
2. To Determine the appropriate depth to underground water at the selected locations

4. METHODS AND MATERIALS

4.1 Study Area Description

The study area is River Onyongo drainage basin in Oju LGA of Benue State, Nigeria;

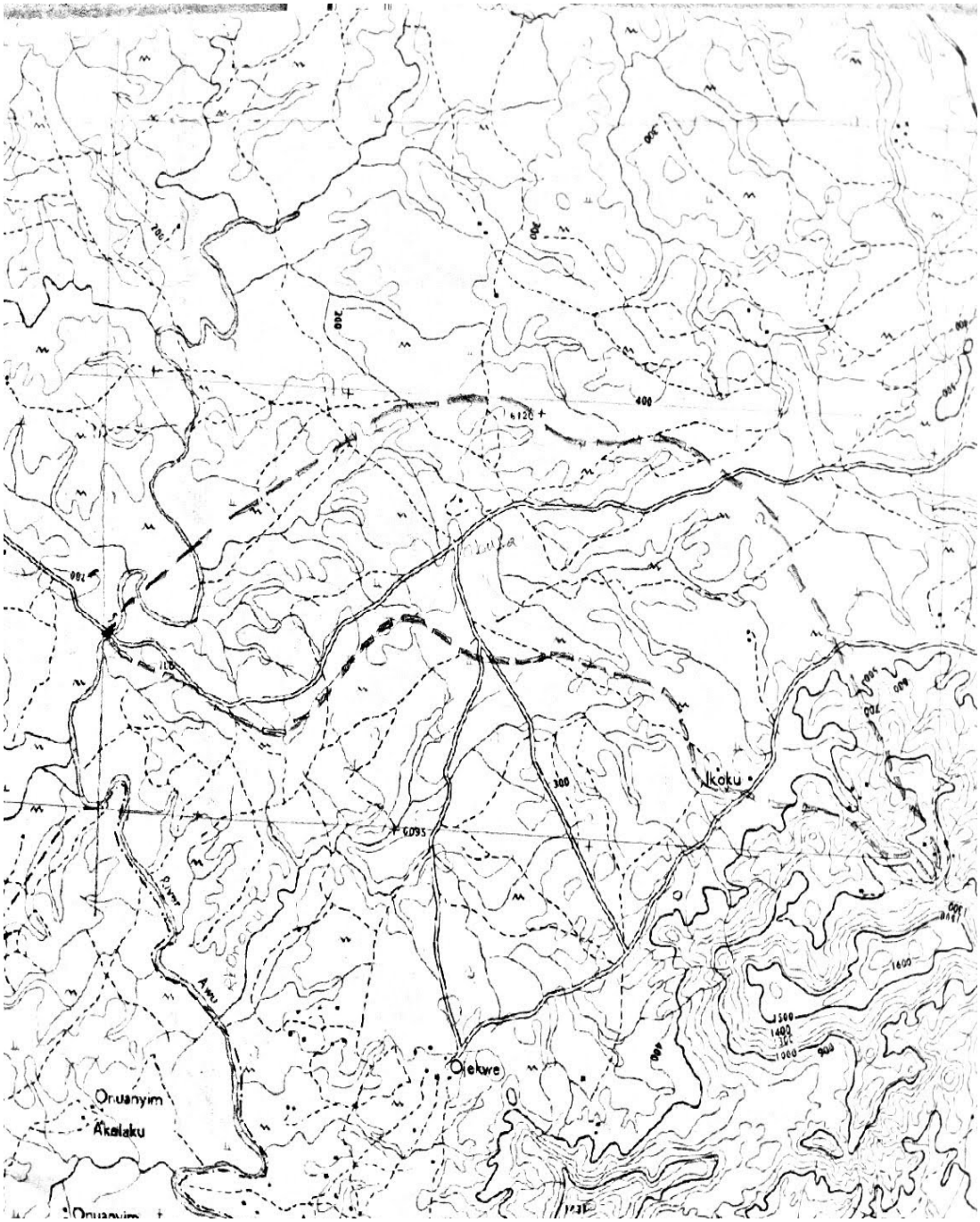

Fig. 1. Topographical map of River Onyongo catchment area

on latitude 7°0.5'N and 7°8'N and longitude 7°46'E and $7^0$58'E. There are motorable roads and footpaths within the area thus, it is quite accessible. The highest elevation in the area is 223 m above mean sea level. The study area is characterized by its tropical climate with two distinct seasons, the wet and dry seasons. The mean annual rainfall ranges from 1200 mm – 1500 mm and occur from April to October with the peak in July/August.

4.2 Methodology

The locations of the sampling units are:

a. River Onyongo at Ubeka – Idelle: right hand and left-hand side of the bridge Ikwokwu
b. Ikwokwu Ainu near hand-dug well at Obaato
c. Ikwokwu Hills
d. River Ichow at Ibussa
e. The topographical map of the Onyongo River is presented in Fig. 1.
f. River Onyongo at Ubeka – Idelle: bearing from the main tarred road is 260ºWSW – the distance from the road to the sampling point is 28 meters left away from the road. Latitude 6º48'51.81"N, longitude 8º14'6.6"E, elevation: 58.2 meters above mean sea level.
g. Ikwokwu – Hills: Elevation; 223 meters above mean sea level, Latitude; 6º47'N longitude 8º20'E
h. Ikwokwu near hand-dug well at Obaato village: Elevation 100 meters above mean sea level, Latitude; 6º47'N longitude 8º20'E
i. Otakini Ainu: Latitude 6º50N, Longitude 8º18'E, elevation: 54.8 meters above mean sea level.

4.2.1 Materials

a. Ranging poles for marking locations
b. Polythene bag – for collection of soil samples
c. Plastic container for water sample collection with a tight cover
d. Cutlass for clearing of footpaths
e. Measuring tape for measuring one point to the other

The materials that were used in the study area are as follows:

1) The topographical map was used to carve out the study area
2) current meter for the measurement of discharge of surface water
3) Global Positioning System (GPS) was used to obtain the coordinates (longitude and latitude); and elevation of the study area
4) Prismatic compass was used to take the bearing of the location during fieldwork

4.3 Water Resources Evaluation

4.3.1 Ground water evaluation

Depth to the water table in existing hand-dug wells in the study areas was measured and recorded.

4.3.2 Surface water evaluation (Discharge measurement)

Discharge measurement of River Onyongo was carried out by bridge method; a heavy iron weight was lowered down from the top of the bridge to determine the depth of the flowing stream. The width of the flowing stream was by a measuring tape. A floating object was used to determine the velocity of the flowing stream.

Discharge of the flowing stream Qm^3/sec = velocity of the flowing stream x cross-sectional area of flowing stream in m^2.

4.3.3 Water quality analysis

Chemical compositions of all the water samples collected from the study area were analyzed in the laboratory using Atomic Absorption Spectrophotometer (AAS) at Benue State Water Board. The concentration of some basic or important cations (Mg^{2+}, Fe^{2+}, Ca^{2+}, and Mn) were determined. Na^{+} and K^{+} were determined using a flame photometer.

Laboratory analysis results were used to calculate the Sodium Adsorption Ratio as follows:

SAR=Concentration of cations in milliequivalent per litre

$$SAR = \frac{Na^{2+}}{\sqrt{\frac{ca^{2+} + mg^{2+}}{2}}}$$

5. RESULTS AND DISCUSSION

5.1 Physical and Chemical Properties of Water of the Study Area

Turbidity: The results of the physical and chemical properties of the water from various locations in the study area are presented in Table 1. The turbidity of water during the rainy season ranged from 0.3 – 25.7 $_{NTU}$, while that of the dry season ranged from 0.03 – 62.5 $_{NTU}$.

The lowest value (0.03 $_{NTU}$) during the rainy season was obtained from Lutheran Church Ubeka (which is the borehole water) and the highest was obtained from River Onyongo (at Ogbella). Generally, rainy season samples have the highest turbidity levels, which could be as a result of water flow and turbulence from the rivers and environment. River Onyongo is the next which had turbidity of 25.7 $_{NTU}$.

The samples from the rivers have the highest turbidity levels. Soil erosion is suspected to be a major contributor to turbid water in the study area, not all eroded soil particles entering rivers and wells in the study areas may cause any major problems. For example, it has been reported that the maximum turbidity of a turbid water layer in a dam reservoir sharply decreased with time after a storm runoff [6,7]. This indicates that most soil particles entering the rivers and wells in the study areas can easily settle to the bottom. Therefore, it is likely to be important to trace and identify the upstream catchment areas containing soils that cause turbidity (at low rates) problems in the rivers and wells. Such efforts may provide useful information for sediment-controlled management because erosion-control practices could be introduced in these areas to forestall any possible surge in turbidity that may exceed the permissible range.

Electrical conductivity: ranged from 28.2 – 838 µs in the rainy season while in the dry season, it ranged from 51 – 862 µs (Table 1). Lutheran Church boreholes at Ubeka had the highest (862_{NTU}) both in the rainy and dry seasons (838 and 862 µs), respectively (Table 1). River Onyongo had low electrical conductivity (28.2 µs) in the rainy season while River Ichow had the lowest (103 µs) in the dry season. The electrical conductivity of the rainwater from Ubeka was 51µs.

The reason for the variation in water EC levels may be attributed to the past and current management practices in and around the rivers and the wells, the location of the water body, and time of year. Possible causes of the variation may include fertilizer use within the area, soil texture, and organic matter content, applications of manure, insecticides and herbicides applications. This agreed with the findings of 2; [7] in their findings of soil electrical conductivity and water content affect nitrous oxide and carbon dioxide emissions in intensively managed soils.

Total Dissolved Solids (TDS): Ranged from 14.4 – 420 ppm in the rainy season and 13.9 - 432 ppm in the dry season across the locations. River Onyongo had the least (14.4 ppm) in the rainy season and 13.9 ppm in the dry season (Table 1) while the borehole at Lutheran Church in Ubeka had the highest (420 and 432 ppm) in dry and rainy seasons respectively. The Lutheran church borehole at Ubeka had the highest in both seasons, and river Onyongo had the lowest (28.2 μ_s). In the rainy season, the rainwater collected had 51 μ_s. Because water EC could be variable, multiple samples were taken from multiple locations.

The pH: ranged from 7.02 – 8.14 in the rainy season (Table 1) and 6.80 and 7.97 in the dry season. The standard is 6.0 – 8.5. These processes tend to cause a lowering of pH (increase in acidity) over time [8]. Some agricultural activities can also accelerate the acidification process. However, most mineral nutrients are readily available to plants when water pH is near neutral therefore, this means that the water pH values in the study area which ranged between 6.80 and 8.14 were all within the permissible range and this implies that agricultural practices in this area will be a little impediment as a result of water pH. Water pH affects the number of nutrients and chemicals that are soluble, and therefore the number of nutrients available to plants. Some nutrients are more available under acid conditions while others are more available under alkaline conditions [9].

Iron (Fe^{2+}): concentration was between 0.05 – 018 mg/l in the rainy season and 0.0 – 0.19 mg/l. in the dry season. These pH values may be linked to the rock from which the soil was formed (parent material) and the water source and the weathering processes that acted on the parent material, for example, climate, vegetation, topography and time. It worth taking note that not all trace elements are toxic and in small quantities, many are essential for plant growth (Fe, Mn, Mo, Zn). However, excessive quantities may cause undesirable accumulations in plant tissue and growth reductions. However, research dealing with the disposal of wastewater has gained sufficient experience to prove useful in defining limitations. It is now recognized that most trace elements are readily fixed and accumulate in soils, and because this process is largely irreversible, repeated applications of amounts above plant needs eventually contaminate soil and may either render it non-productive or the product unusable. Both the rainy and the dry season fall within the usual range.

Magnesium (Mg^{2+}): Concentration in the rainy season ranged from 20 – 60 mg/l and 20 – 40 mg/l in the dry season (Table 1). Ikwokwu had highest in the rainy season (60 mg/l) and 40 in the dry season. The lowest (20 mg/l) in the rainy season was obtained at Ubeka, Otakini and in

the dry season was 20 mg/l at River Onyongo and rainwater.

At present, there is a reasonably good agreement that magnesium acts on soils in a way which is more like calcium than sodium, and that it is preferentially adsorbed by the soil to a much greater degree than sodium but to a slightly less degree than calcium [10]. The effect may be due to a magnesium-induced calcium deficiency caused by high levels of exchangeable magnesium in the water. Some research evidence showed that yields of crops such as barley, wheat, maize and sugar-beets are reduced when the Ca/Mg ratio in soil-water is less than one calcium [10].

The Calcium (Ca^{2+}): concentration ranged from 40 – 60 mg/l in the rainy and dry seasons respectively. River Onyongo at Ogballa and Ubeka had the concentration of (60 mg/l) during the rainy season (Table 1). River Ichow at Ibussa, Ikwokwu and Otakini had 40 mg/l in the rainy season, and the rainwater collected had 40 mg/l. In the dry season, River Ichow at Ibussa had 40 mg/l. River Onyongo, Lutheran church Ubeka, Ikwokwu and Otakini Ainu had 60 mg/l during the dry season. There are insufficient data to make either the Ca/Mg ratio or the calcium to total cation ratio an evaluation factor when judging the suitability of water for irrigation, but if irrigation water is being used that has a Ca/Mg ratio less than one, or calcium to total cation ratio less than 0.15, further evaluation is needed [11]. Although no conclusive recommendations can be made, such water may pose a potential problem related to plant nutrition and evaluation may be needed to determine if a readily available source of soluble calcium exists in the soil or whether further studies are needed to determine if calcium should be added as a fertilizer or soil amendment. However, rivers Onyongo, Ubeka, Ikwokwu and Otakini Ainu have 60 mg/l permissible concentration is 75.0 mg/l.

Sodium (Na^{+}) concentration ranged from 0.33-11.94 mg/l (Table 1) in the rainy season and 1.48-10.7 mg/l in dry season while the rainwater collected had the concentration of 0.84 mg/l. Ubeka borehole had the highest (11.94 mg/l) and river Ichow at Ibussa was lowest (0.33 mg/l) in the rainy season. Ikwokwu had the highest (10.7 mg/l) and lowest (1.48 mg/l) in the dry season. The rainwater had Na^{+} concentrations of 0.84 mg/l. All values across the locations are within the normal range of 0-40 mg/l.

The Sulphate (SO_4^{2-}): Concentration ranged from 8.0-201 mg/l in the rainy season (Table 1) and between 9.0 and 20 mg/l in the dry season while the rainwater collected had 4 mg/l. The Lutheran church at Ubeka had the highest (201 mg/l) $^{-}$ concentration while River Onyongo and Otakini had the least (8.0 mg/l) in the rainy season. In the dry season, the least (9.0 mg/l) was obtained from Ikwokwu while 21.0 mg/l was the highest at Otakini Ainu and the rainwater was 4 mg/l. The Characteristic Na soils from the agricultural standpoint are that they contain sufficient exchangeable sodium that can adversely affect the growth of most crop plants and this may be the responsible for the monumental low crop performances in these areas. For a definition, sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15. Excess exchangeable sodium harms the physical and nutritional properties of the water, with the consequent reduction in crop growth, significantly or entirely [12]. But the water analysed were good for irrigation, also the soils ranged from low to moderate only for River Onyongo where the values range from moderate to high. These small particles move into H_20 and could block the soil pores that are so important for plant growth and gaseous exchange. All of these values of sulphates are within the usual range except at Ubeka where the concentrations were slightly about the permissible range. The concentrations of sulphate could be derived from parent material that must have released the compound to the water; the fertilizers being used in these areas, other chemicals such as herbicides and fungicides may also have contributed to the concentration of this compound as suggested by 11.

Nitrate (NO_3^{-}): concentration ranged from 0.90 - 2.80 mg/l in the rainy season (Table 1) and 0.73-18 mg/l in the dry season. The rainwater had 0.59 mg/l. Ikwokwu had the highest NO_3^{-} concentration (2.80 mg/l) in the rainy season while Otakini had the lowest (0.90 mg/l). River Ichow at Ibussa had the lowest concentration (0.73 mg/l) the in the dry season and Otakini Ainu had the highest value (18 mg/l). Although geologic units can contribute nitrate to groundwater (Boyce et al., 1976), sources of nitrate in these locations may have majorly occurred at the land surface. Shallow groundwater is another possibility for the relatively higher concentrations of nitrates in these locations (though within the permissible range for irrigation). Sandy soils are prone to

Table 1. Physical and chemical properties of the water from various locations

Location	pH	Turb. (NTU)	E.C (µs)	TDS (ppm)	Fe^{2+}	Mg^{2+}	Ca^{2+}	Na^{+}	SO_4^{2-}	NO_3^{-}	Cl^{-}
					→			mg^{-3+}	←		
Rainy season											
River Ichow at Ibussa	8.14/guidelines values	3.75	60.1	29.5	0.01	40	40	0.33	26.0	1.60	195
River Onyongo	7.76	25.70	28.2	14.4	0.18	40	60	3.54	8.0	1.62	86
Lutheran Church Ubeka	7.02	0.25	838	420	0.05	20	60	11.94	201.0	2.60	45
Ikwokwu Hand Pump well	7.61	0.44	407	203	0.07	60	40	11.71	14.0	2.80	82
Otakini by Hand Pump	7.68	0.30	28.3	142	0.05	20	40	1.25	8.0	0.90	22
Dry season											
River Ichow at Ibussa	7.55	62.50	103	51.6	0.19	40	40	5.0	18.0	0.73	113
River Onyongo	7.97	11.10	276	13.9	0.10	20	60	1.48	12.0	0.76	18
Lutheran Church at Ubeka	6.80	0.03	862	432	0.02	40	60	6.2	21.0	0.81	174
Ikwokwu Hand Pump Well	7.53	0.23	402	201	0.04	40	60	10.2	9.0	1.82	35
Otakini by Hand Pump	6.96	0.30	466	233	0.0	40	60	1.9	20.0	18	78
Block Industry Ibussa Rain Water	7.65	1.46	51	25.6	0.08	20	40	0.84	4.0	0.59	12

Table 2. Sodium Adsorption Ratio (SAR) of water sources in rainy and dry seasons

S/N	Location	Rainy season	Dry season
	River Ichow at Ibussa(upstream)	0.0088	0.3
	River Onyongo at Ubeka – Idelle	0.087	0.042
	Otakini Ainu	0.037	0.47
	Ikwokwu Ainu near hand dug well at Obaato	0.3	0.3
	Lutheran Church Ubeka	0.34	0.15
	Rain water at Ibussa	0.027 Me/L	-

Table 3. Determination of Coefficient of Permeability of Soil/Lithology by Darcy Formula Q = KIA (Field permeameter)

Location	Coefficient of permeability		Soil category	
	Rainy season	Dry season	Rainy season	Dry season
River Ichow at Ibussa	24.0	29.5	Coarse grain sand	Coarse grain sand
Ubeka Idelle	0.36	1.0	Fine grain sand	Fine grain sand + clay
Otakini Ainu	17.12	4.06	Medium grain sand	Medium grain sand
Ikwokwu Obaato near Hand dug well	1.10	4.76	Fine grain sand	Medium grain sand

Table 4. Depth to water table in hand dug wells at various locations

Locations	Depth to water table (m)
Ibussa block industry Oju	4.9
Ikwokwu Owokwu	3.4
Close to Lutheran church Across the tarred road	5.8
Ikwokwu Obaato	6.7
Reservoir between Ibussa and Ikwokwu	5.0

Table 5. Discharge measurements in River Onyongo and Ichow

Season	River Onyongo	River Ichow
Rainy	199,888.12 litres per sec	354.3 litres per sec (bridge) 195.43 litres per sec (upstream)
Dry	2,770.62 litres per sec	No flow in the dry season

nitrate contamination [13,14] in their studies revealed that irrigation wells generally were deeper (21 – 38 m; 70 – 125 ft) and yielded water with lower N concentrations than shallower (12 – 24 m; 40 – 80 ft) domestic wells. The type of well, well-depth, and depth below the water table are other possible factors that influence nitrates concentrations in water.

Chloride concentration ranged from 22.0-195.0 mg/l in the rainy season (Table 1) and 18.0-174 mg/l in dry season while the rainwater had 12 mg/l. Otakini had the lowest (22 mg/l) and River Ichon had 195 mg/l as the highest in the rainy season. In the dry season, River Onyongo was lowest (18.0 mg/l) and Lutheran church at Ubeka had the highest (174 mg/l.). The concentration of chloride ranged from 22.0 - 195.0 mg/l in the rainy season and 18.0 - 174 mg/l in dry season 12 mg/l in the rainwater. Otakini had the lowest (22 mg/l) and River Ichon had (195 mg/l) the highest in the rainy season. In the dry season, River Onyongo had 10.0 mg/l as the lowest and Lutheran church at Ubeka had the highest (174 mg/l). The permissible concentration is 200.0 mg/l. The relatively high concentrations (though within the permissible range) of chlorite might be due to percolation of ions formed during the slow decomposition of hypochlorite solutions [15-17], especially at warm temperatures due to the facts that the study area is in the southern guinea savanna of Nigeria. However, the available chlorine concentration decreases with time.

5.2 Sodium Adsorption Ratio (SAR)

The sodium adsorption ratio values are presented in Table 2 which ranged from 0.0088 mg/l in the rainy season to 0.3 mg/l in the dry season. In Ubeka Idelle near River Onyongo the

SAR was 0.087 in the rainy season and 0.042 mg/l in the dry season. At Ikwokwu the SAR was 0.3 mg/l in both rainy and dry season. At the borehole in Lutheran Church Ubeka the SAR was 0.34 and 0.15 mg/l while the rainwater at Ibussa had 0.027mg/l. In a situation whereby, sodium ions are high in water, it affects the permeability of the soil and causes infiltration problems. This is because sodium, when present in the soil in exchangeable form replaces calcium and magnesium, adsorbed on the soil clays and causes dispersion of soil particles (if calcium and magnesium are the predominant cations adsorbed on the soil exchange complex, the soil tends to be easily cultivated and has a permeable and granular structure) [18]. However, this characteristic was not observed in the study area because SAR was largely within the permissible range.

5.3 Coefficient of Permeability of Soil/Lithology by Darcy Formula

The range of coefficient of permeability by Darcy's formula was between 0.36 and 24 m/day in the rainy season and 1.0 and 29.5 m/day in the dry season. The highest values in the dry and rainy seasons were 29.5 and 24.0 m/day both at River Ichow Ibussa, respectively (Table 3). The values correspond to that of sieve analysis K where River Ichow still had the highest values of medium-grained especially the soils at Ubeka Idelle, Otakini Ainu and Ikwokwu Obaato were mostly fine-grained sand + clay medium-grained to coarse-grained sand (0.36 – 29.5 m/day in the above locations) which invariably agrees with the findings of 9. However, Ichow had 24.0 m/day in the rainy season and 29.5 m/day in the dry season which makes this location impermeable as compared to the other locations. These values are similar to the coefficient of permeability by K [19]. The porosity of coarse grain sand at Ichow showed that the soils in this location are distinctively porous suggesting it originates from variable parent materials [20].

5.4 Depth to Water Table

The results of the depth to the water table of hand-dug wells at various sites are represented in Table 4. At Ibussa block industry the depth was 4.9 m. At Ikwokwu – Owokwu it was 3.4 m. The Lutheran church well is 5.8 m. At Ikwokwu Obaato and the reservoir between Ibussa and Ikwokwu they are 6.7 and 5.0 m respectively. The depth to water table taken from the hand-dug well ranged from 3.4 – 6.7 m in the various locations within the catchment area and all of these wells were dry during the dry season and the reservoir. On April 12th, 2019, all the wells dried up and the rivers visited were almost dry. This was in agreement with the findings of 15; 17 separately reported that Oju has fluctuating water characteristics. Most of the Rivers visited by Onah and Ochere around March, 2016 have stopped flowing.

Groundwater quality and depth to water table have a direct impact on soil health and subsequently crop yields. Good quality groundwater at an optimum water-table depth can increase crop yields by providing the much-needed water to the plant roots in the absence of irrigation or rainfall. Poor quality groundwater will decrease soil health and plant growth when it is shallow enough to be drawn into the rooting zone of crops [21]. Irrespective of the groundwater quality, if water-table depth rises close to the surface more soil pores will be filled with soil water which depletes oxygen within the plant root zone.

5.5 Discharge Measurement of River Onyongo and Ichow

The discharge measurement of River Onyongo and Ichow (Table 5) showed that the rainy season had the highest (199,888.12 litres per sec) in Onyongo while the least discharge was 195.43 litres per sec (upstream) in Ichow at the bridge and 354.3 litres per sec at the upstream. In the dry season, it was about 2,770.62 litres per sec in Onyongo and no flow during the dry season. River Ichow, near the bridge and upstream had a discharge of 354.3 and 195.43 litres per second in rainy season respectively while the dry season had no flow. The river is deeply entrenched to about 1.2 m in the dry season and 7.2 m in the rainy season. Bedrock was exposed in the river bed of which was seen megascopically to be shale. River Ichow and Onyongo were visited between March and April 2019 and August and September.

6. CONCLUSION

The water samples analyzed showed no salinity as the pH is within the permissible levels likewise other parameters analysed are all within the permissible levels except for Sulphate ($S0_4^{2-}$) in Lutheran church Ubeka, the concentration is 201 mg/L and the permissible level is 200 mg/L but for electrical conductivity (E.C) is far above the permissible level in all the locations.

The coefficient of permeability showed a similar pattern of permeability which indicate that the soils in the study area are predominantly from medium-fine grained sand-clayed materials and in one of the sampling units it shows gravel + coarse sand. From the information obtained of particles size, soil texture, the rainfall, water drains properly, well enough for agriculture with the appropriate management practices.

The wells in the study area are quick to dry, as all the wells recorded in the study area were dry in the dry season. According to the VES data obtained, the depth of drilling is about 42 – 52 m. but, the depth of drilling to obtain freshwater was 6 m above which will be saline. The variation of soils in the study area could be due to the differences of the parent materials, introduction of foreign materials, climatic conditions, living organism and topography.

By our assessment, the surface and groundwater in the study area are quick to deplete and to rise to water table during the rainy season and drops in the dry season. The surface water (River) gives low yield in the dry season with 2770.62 litres of water and 199,888.12 litres in rainy season in Onyongo River, and in Ichow, the dry season is completely dry of water in the river bed and 354.3 litres in the rainy season. The groundwater is usually fresh at a shallow depth in the rainy season and mostly empty in the dry season with most of the wells are within the depth of 3.4 - 6.7 m. further, than this will be characterized by hardness and salinity. The soil particle size distribution can support irrigation and also yield well when properly managed. It also can retain moisture.

7. RECOMMENDATIONS

In the backdrop of analysis and results, the following recommendations are made;

1. Groundwater was available for irrigation during dry season therefore, dams should be constructed to impound water for irrigation purpose in the dry season.
2. Traditional water harvesting should be encouraged to save water for the dry season.
3. Drilling depth for water should be 5 – 6 m (at Ubeka Idelle) to obtain fresh water.
4. Maximum drilling depth should be about 52 – 54 m (at GSS Ibussa) after which the water will become saline.
5. Dry season farming is recommended for Otakini Ainu, Ubeka and Ichow due to their high surface water retention ability. They will require very little or minimal water supply during irrigation.
6. Intelligent macro and micro watershed management for better water management and erosion control.
7. Role of INGOs and NGOs for soil conservations.
8. Further research to be undertaken on this subject/theme.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Barett-Lennard EG. Restoration of saline land through revegetation. Agricultural Water Management. 2002;53(1-3):213-226.
2. Buccolieri A, Buccolieri G, Dell'Atti A, Strisciaullo. Giuseppe and Gagliano-Candela R. Monitoring of total and bioavailable heavy metals concentration in agricultural soils. Environmental Monitoring and Assessment. 2010;168:547–560.
3. Joseph EA, Blessing O. Water as a driver for sustainable development and poverty eradication. Book of readings: 6th National Water Conference; 2016.
4. Spon EF. Water pollution control - A guide to the use of water quality management principles. St Edmundsbury Press, Bury St Edmunds, Suffolk. 1997;526.
5. Seiber U. Languages of Benue State. Nigerian Languages. Department of Languages and Linguistics, University of Jos. Archived from the original; 2007.
Available:https://en.wikipedia.org/wiki/Benue_State
6. Shin M, Lee J, Seo E. Effect of muddy water on the fishes in Imha Reservoir. Journal of Life Science. 2009;19(8):1112-1118.
7. FAO. Water Quality for Agriculture. Irrigation and drainage paper 29 ref 1 role: FAO; 1994.
8. Deckers MB, Breitburg DL, Marcus NH. Geographical differences in behavioral responses to hypoxia local adaptation to an anthropogenic stressor Ecological. Application. 2001;13:1104–1109.

9. Richards LA. Diagnosis and improvements of saline and alkaline soils. Agriculture Handbook. No. 60.United States Department of Agriculture, Washington, DC. 1954;55–67.
10. Rahman WA, Rowell DL. The influence of magnesium in saline and sodic soils properties or a problem of cation exchange. Journal of Soil Science. 1979;30:353-546.
11. Girdhar IK, Yadav JSP. Effect of different Mg/Ca ratios, SAR values and electrolyte concentrations in leaching water on dispersion and hydraulic conductivity of soil. Salt Affected Soils, Karnal. 1980;202–209.
12. Available:http://www.fao.org/3/x5871e/x5871e05.htm
13. Sophocleous M, Townsend MA, Orountiotis C, Evenson RA, Whittemore DO, Watts CE, Marks ET. Movement and aquifer contamination potential of atrazine and inorganic chemicals in central Kansas cropland: Kansas Geological Survey, Ground Water Series; 1990.
14. Townsend MA, Marks ET. Occurrence of nitrate in soil and ground water in south-central Kansas; In, Proceedings: Ground Water Management, Cluster of Conferences, Kansas City, Missouri, 20–21 February: National Water Well Association, Dublin, Ohio. 1990;145–15.
15. Adam LC, Fabian I, Suzuki K, Gordon G. Hypochlorous acid decomposition in the pH 5–8 region. Inorganic Chemistry. 1992;31:3534–3541.
16. Hutchison J, Mole N, Fielding M. Bromate and chlorate in water: The role of hypochlorite. In: Proceedings of the First International Research Symposium on Water Treatment By-products. Organized by Groupement de Recherché Universities sur les Techniques de Traitementetd' Epuration des Eaux (GRUTTEE). 1994;29–30.
17. Stanford BD, Pisarenko AN, Snyder SA, Gordon G. Perchlorate, bromate and chlorate in hypochlorite solutions: Guidelines for utilities. Journal of American Water Works Association. 2011;103:1–13.
18. Walworth JL. Soil sampling and analysis. Arizona Cooperative Extension. College of Agriculture and Life Sciences, University of Arizona.p1Foth, H. D. (1984). Fundamentals of Soil Science 7th Edition, New York: John Wiley and sons Inc. 2006;463.
19. Foth HD. Fundamentals of soil science 7th edition, New York: John Wiley and sons Inc. 1984;463.
20. Odong J. Evaluation of empirical formulae for determination of hydraulic conductivity based on grain-size analysis, The Journal of American Science. 2007;4:1–6.
21. Dresboll DB, Thorup-Kristensen K. Crop yield, root growth and nutrient dynamics in a conventional and three organic cropping systems with different levels of external inputs and N re-cycling through fertility building. Department of Plant and Environmental Science, University of Copenhagen: Taastrup. 2012;8–61.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/56392