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Comparative Analysis of Aquifer Properties in Selected Geologic Terrain in Nigeria

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ABSTRACT

Aim of the Study: Two main geologic terrains of basement complex and sedimentary areas were investigated for underground water production capacity by evaluating the aquifer properties. The assessment was done by evaluating 19 boreholes in the two terrains. TK1-TK10 constituted the boreholes from basement area, while AK1-9 constituted boreholes of sedimentary terrain.

Methodology: Pumping rate of the boreholes were crucial to establish the water production capacity from the geologic terrains. Dipper, stopwatch, graduated plastic container, 1 h.p submersible pump, 5.5 KVA generator and field notebook were materials used to collect the field data. Suitable measuring datum of 0.5 m was taken from the ground level for all measurements. SWL was taken and stopwatch was on simultaneously, just as pumping exercise began. The discharge rate was measured then recovery period monitored as pumping stopped.

Findings: Findings of the study revealed Akerebiata sedimentary wells have SWL with 2.8-5.9m, DWL recorded 18.1-28.2m, yield varied between 0.49-0.93L/sec, RDD was measured to be 0.01-0.09m. Specific capacity was calculated to be 42.33-80.35m^3/day/m while DWS recorded 0.1-0.2m. Conversely, Tanke wells were pump tested and revealed SWL varied between 6.1 and 8.9m, DWL recorded 48.2-96.2m, yield varied between 0.51-0.72L/sec, RDD was measured to be 0.09-0.18m. Specific capacity was calculated and range from 44.06 to 61.34m^3/day/m. DWS recorded for Tanke wells ranges from 0.1 to 0.3m.

Conclusion: The study concluded that the Akerebiata wells are having the potential to produce more underground water than their counterpart i.e., Tanke wells. Recommendation of 0.8-1.3 meters as DWS in the sedimentary terrain and 0.6-1.0 meters in basement complex terrain will allow such wells to last minimum of 10 years before a new well development can be initiated for removal of impurities.

Keywords: Static Water Level, Dynamic Water Level, Residual Drawdown, Specific Capacity and Dead Water Stock.

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Introduction

Ground water is widely distributed in the earth and it's a replenishable resource unlike so many other resources of the earth. It is worthy of note that a water bearing geologic formation or stratum capable of transmitting water through its pores at a rate sufficient for economic extraction by wells is called an aquifer. Groundwater in form of boreholes and shallow wells is currently the major source of potable water constituting about 93% source for households in Africa and Nigeria inclusive and as reported in this article. Furthermore, Formations that serve as good aquifers for the water include consolidated gravels, sands, alluvium, lake sediments, glacial sandstones, limestones with cavities (caverns) formed by the action of acid waters, granites marl with fissures and cracks, weathered gneisses, schists, quartzites etc. Aquifers perform two important functions ie storage function and a conduit function. In otherwords, aquifers store water and also function as a pipeline. Larry (2011).When water is drained from a saturated geologic material under the influence of gravity only a portion of the total saturated volume in the pores is released.

The need for the comparative analysis of the geologic terrain for their water production capacities will give the basic information of the most suitable area for underground water production using salient test parameters like yield, static water level, dynamic water level, drawdown, residual drawdown, specific capacity etc. Ground water also play a vital role in exploitation ie production of hydrocarbon by driving and sweeping out oil from their respective carbonate and sandstone reservoirs before the introduction of other varieties of external enhancement recovery technique. Ibrahim et al (2019 and 2020).

Location of Study Area

The sedimentary and basement terrains are located around Akerebiata and Tanke areas respectively all in Ilorin metropolis. Tanke area serve as the gateway to the only campus to University of Ilorin, while Akerebiata serve as the gateway to Nigeria Army Corps ie Sobi barracks and further down to Kwara state University, Malete. These two areas are known for good underground water production with varying water table that will need be estimated and conserved for proper utilization with the emerging global trend of climate changes associated with unpredictable rainfall pattern globally.

Tanke well location Akerebiata well location

Fig. 1: Earth map of Kwara state showing the location of the study areas.

Materials and Methodology

The materials used for the study included among others the aquifer test equipments like dipper ie dip meter, graduated measuring can (20 liters capacity), 5.5 KVA generator, fuel, stop watch, discharge pipes, $1^{1/4}$ main riser pipe, 1 hp submerisible pump and field note book. 9 selected household boreholes of sedimentary terrain called Akerebiata wells ie AK1-AK9 were selected for the purpose of pumping test exercise, while 10 selected boreholes at Tanke area ie TK1, TK2, TK3, TK4-TK10 were available for the assessment to determine their aquifer properties. It is worthy of note that these boreholes were pump tested with 1 hp submersible pump and at full discharge and no gate valve to regulate the flow of water from the aquifer to riser and onward to the discharge pipes. Pumping tests being a practical way of obtaining ideal data of the borehole's efficiency and its optimal production yield was thus adopted for this study. The way in which the water levels responded to the pumping exercise was closely monitored, then analysed to derive maximum information about the performance characteristics of the boreholes and the hydraulic properties of the aquifers in question.

Results and Discussions

Static water level was first measured in each well before pumping began. It depicts the water level at rest in the boreholes before any pumping exercise commenced. The pumping exercise was achieved with constant discharge from each borehole at full gate valve opening while a stopwatch was simultaneously set to record the time taken, in seconds, to fill the graduated 20 liters container. This process was repeated for several hours for each of the selected boreholes. It was therefore observed that the water level and the drawdown in the boreholes were constant throughout the hours of pumping exercise.

Constant Discharge Test

With the constant discharge from the boreholes, pumping persisted and a state of equilibrium was quickly maintained and sustained for some minutes between the rateof discharge and the rate of recharge from the aquifer, hence DWL established. In this condition of equilibrium, the rate of pumping or discharge is directly proportional to the recharge as such position of major fractural aquifer recoded that supply the borehole water. Gradual further reduction in the water column persisted after sometime. As pumping exercise stopped which signify that water in the well finally exhausted, then new time was set to begin at zero second to spontaneously start taking the recovery rate defined by the recharge of the boreholes. This was monitored to see whether it will recharge to the original position of static water level that was originally recorded, as such, the residual DD established between the new position and original SWL. The following results were obtained from the pumping test exercise.

Table 1: *Aquifer properties of selected boreholes from Akerebiata sedimentary area.*

BCDs	Depth (m)	SWL (m)	TPT (secs)	DWL (m)	Yield (L/sec)	TDD (m)	TRT (sec)	RDD (m)
AK1	48.2	3.5	17956	28.2	0.79	44.6	1848	0.04
AK2	59.1	3.6	19219	19.3	0.93	55.3	1734	0.01
AK3	42.7	4.9	19892	18.1	0.84	37.8	1832	0.03
AK4	49.3	5.9	19497	23.4	0.49	43.4	2021	0.09
AK5	61.3	2.8	19011	25.9	0.59	58.5	1729	0.08
AK6	57.4	3.5	17991	24.3	0.77	53.9	1945	0.03
AK7	49.1	4.5	18893	21.9	0.81	44.6	1834	0.04
AK8	47.2	3.6	19922	24.6	0.82	43.6	1989	0.08
AK9	52.3	3.8	19912	22.3	0.77	48.5	1978	0.06

SWL= Static Water Level, TPT= Total Pumping Time, DWL= Dynamic Water Level, TDD= Total Drawdown, TRT= Total Recharge ie recovery Time, RDD= Residual Drawdown and DWS= Dead Water Stock

Static and Dynamic water levels of Akerebiata wells

The water level at rest ie SWL was measured as 3.5m for AK1 borehole with a total depth of 48.2 meters, while AK2 recorded 3.6m SWL at a depth of 59.1m. These two boreholes were pumped at constant discharge for about 17956 and 19219 seconds respectively. In essence, they were pumped for 299and 320 minutes respectively. The corresponding DWL was measured to be 28.2 and 19.3 meters respectively. This signifies the occurrence of major fractural trend at these depths supplying the boreholes water recharge, because the drawdown remained in this position for a longer time of about 291 seconds before dropping further. At this point, equilibrium between discharge and recharge of the boreholes were noticeable and taken at these depths as DWL. AK3 and AK4 of 42.7 and 49.3m depths also revealed SWL of 4.9 and 5.9 respectively. Total pumping time (TPT) was estimated to be19892 and 19497 seconds. Dynamic water level recorded were 18.1 and 23.4m and this was interpreted as the position of the first aquifer that supplies the borehole with underground water. At these points, the equilibrium of discharge and recharge rate during the pumping exercise was almost equal and that was the reason for the standstill of the water in the borehole column for some moment of the operation.

Similarly, boreholes AK5, AK6, AK7, AK8 and AK9 of 61.3, 57.4, 49.1, 47.2, 57.3m total depths all recorded static water levels of 2.8, 3.5, 4.5, 3.6, 3.8 m respectively. More importantly, borehole AK5 recorded the deepest among all the investigated wells with SWL of 2.8m, while AK3 with a total depth of 42.7m recorded one of the deepest SWL of 4.9m. Furthermore, the TPT of these 5 boreholes ranges from19922-17991 seconds with the borehole AK5 recording 9011 seconds and AK9 recording 19912 seconds respectively. The DWL of these five wells ie AK5-AK9 showed 25.9, 24.3, 21.9, 24.6 and 22.3m. The values obtained for these boreholes showed the investigated boreholes had the discharge rate to be at equilibrium with the recharge from the aquifers at almost the same positions of enumerated DWLs recorded. This was the reason there was a momentarily standstill of the water in the columns at points of establishment of their equilibrium occurring at varying depths and was advanced by Ibrahim et al (2023).

Yield of the Akerebiata Boreholes

The yield of the selected boreholes were measured to establish the water production capacities. AK1 borehole produced 0.79 liters per second of pumping, as such, with a TPT of 13956 seconds, the volume of water produced was estimated to be 232liters per minute. Similarly, AK2 borehole had a yield of 0.93l/s, which is quite high for a borehole of 50.1 meters depth has been able to produce 320 liters per every minute. This is quite outstanding with an excellent recharge of 28.9 minutes for total recharge time (Table 1). It can be interpreted that this borehole can serve industrial and irrigation purpose due to its excellent recharge capacity. The yield of AK3 borehole was measured to be 0.84 l/sec. Furthermore, AK4, AK5, AK6, AK7, AK8 and AK9 boreholes were measured to be 0.49, 0.59, 0.77, 0.81, 0.82 and 0.77 L/sec respectively. The high pumping rate time could be ascribed to two main factors of being a sedimentary terrain commonly prolific for underground water production and setting the submersible pump at full discharge with no gate valve to control the flow of the water from the aquifer. Most boreholes in this terrain can serve industrial purpose with excellent yield recorded.

Total Drawdown of Akerebiata Wells

Total drawdown for the boreholes were measured to give more detail aquifer properties of the wells in the area. The total drawdown (TDD) refers to the total depleted column of water from the initial water level at rest ie SWL. Pumping exercise continued till the point the borehole stopped pumping ie total exhaustion of the borehole water. In essence, the difference in varying depths at these points and the static water levels gave an estimate of the TDD of each of the investigated boreholes, with DWS of 01-02m across the wells (Tables 1 and 3). In AK1 borehole, TDD was measured to be 44.6m with only 0.1m left in the borehole as dead stock level (DWL) that cannot be pumped from the water column.

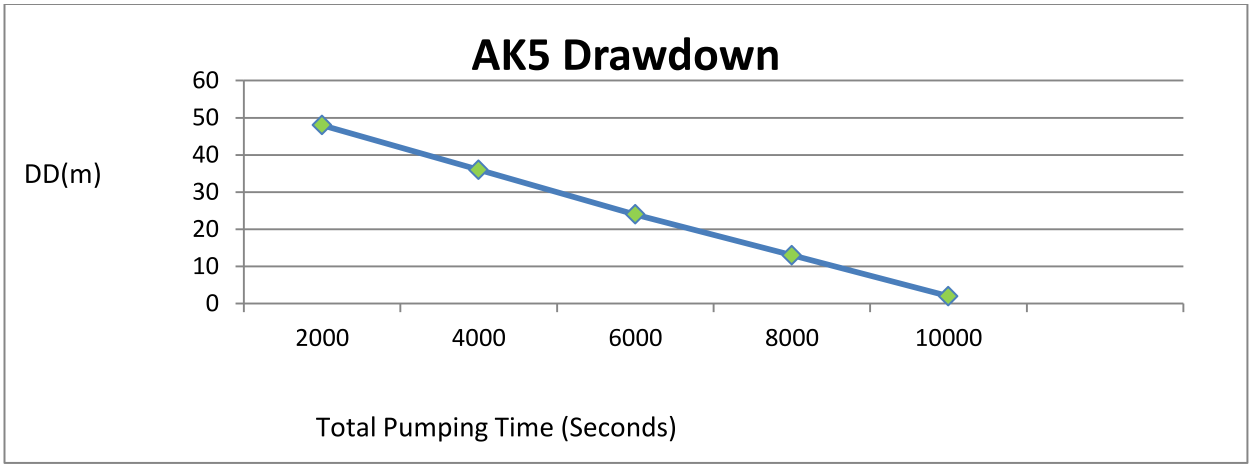

Fig. 2: Detail of drawdown graph of AK5 borehole

The best dead stock in any sedimentary borehole should be 0.8-1.3m as this has been properly researched by Ibrahim et al (2023). In basement complex boreholes, DWS of 0.6-1.0m is ideal to prevent sucking of fine grained sand and mud particles into the submersible pump, ensure purity of the underground water and enhance the long span performance of the pump. This will allow the submersible pump to last longer and infiltration of fine size mud and sand particles will not find their way easily into the water well. AK3, AK4, AK5 and AK6 all recorded TDD of 37.7, 43.3, 58.4 and 53.8 m with dead water stock (DWS) of 0.1m recorded across the wells.. AK7, AK8 and AK9 equally recorded TDD of 44.4, 43.5 and 48.4m respectively.

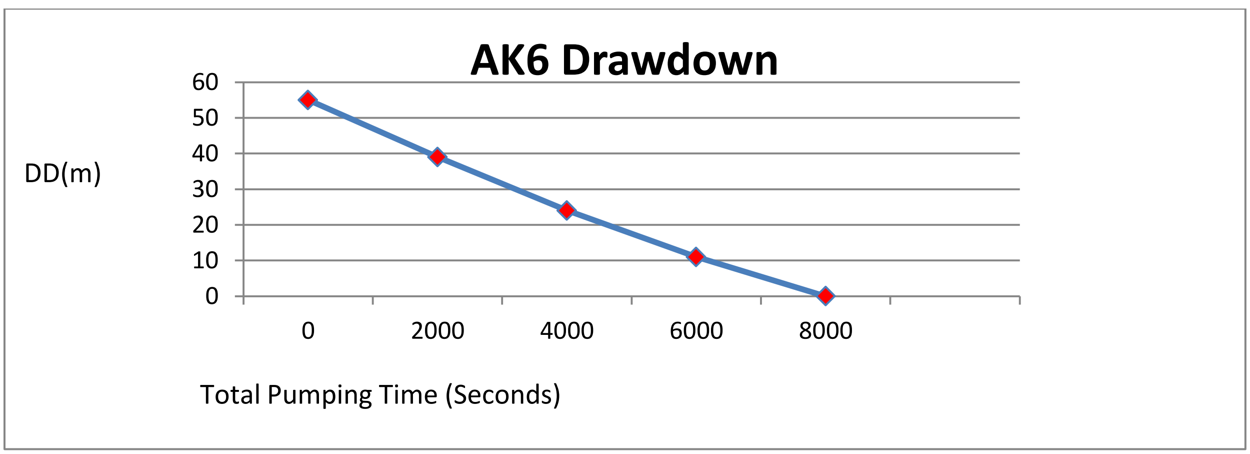

Fig. 3: Detail of drawdown graph at AK6 borehole

Residual Drawdown of the Boreholes (RDD)

This is commonly referred to as the minute difference in water column of the original level before pumping began ie SWL and the level reached after full recovery ie recharge of such boreholes. Studies have shown that this difference in this water depth is a function of the hydraulic conductivity and transmissivity of the borehole water with characteristic formation of cone of depression to reflect total area of influence during pumping exercise. In AK1, AK2, AK3 and AK4, the residual drawdown recorded were 0.04, 0.01, 0.03 and 0.09m respectively. In AK5, AK6, AK7, AK8 and AK9 the residual drawdown (RDD) recorded included 0.08, 0.03, 0.04, 0,08 and 0.06m respectively. Previous hydrogeological studies of boreholes from different parts of Nigeria for underground water production have all revealed that as the boreholes age in time, the residual drawdown increases and widens. Ibrahim et al (2023).

Specific capacity and Dead Water Stock analysis of Akerebiata Wells

The specific capacity and Dead water stock of the wells at Akerebiata boreholes that represent the sedimentary terrain was measured and the following results obtained (Table 2).

Computation of the Specific capacity of the boreholes was done with utilization of some mathematical relationship using the basic concept. ie S_w.(m^3/day/m) = Q/DD. Where S_w. = specific capacity, Q = Quantity of water discharge ie yield (L/sec) and DD represent the Drawdown of the wells (m). On the other hand, dead water stock analysis was calculated as the water column difference between the total depth of each well (T. Depth) and their corresponding installation depths (I. Depth). Here, it varied from 0.1 to 0.2 meters water column (Table 2).

This specific capacity is a measure of the effectiveness of the wells, it decreases with the increase in the pumping rate and prolonged pumping time (seconds). In essence, the quantity of water a given borehole can produce per unit of drawdown is referred to as the specific capacity. Dead water stock refers to the water zone commonly trapped in the well and the maximum pumping exercise cannot produce. Ibrahim et al (2023). This zone of water in the borehole is commonly created as a result of difference in the total recorded depth of the well and the submersible installed pump depth. At Akerebiata area, the analyzed 9 boreholes for these aquifer parameters are tabulated (Tables 1 and 2). These parameters gave rise to the DWS and revealed their varying specific capacities (Table 2). The installation depths which refers to the depth of coverage of submersible pump in the well has a 1 h.p submersible pump in size.

More importantly, since 1 Liter = 86.4 m^3/day, then all measured values in L/secs as water discharge (Q) ie yield and as contained in Tables 2 and 4were converted to m^3/day, then to m^3/day/m as the specific capacity by putting into consideration the drawdown (DD) in meters. This method of conversion was applied for the calculation of the specific capacities of Akerebiata and Tanke wells (Tables2and 4).

Table 2: *Specific capacity and Dead Water Zone i.e. stock of Akerebiata wells*

S/N	**BHC**	**T. DEPTH (m)**	**I. DEPTH (m)**	**DWS (m)**	**YIELD (l/s)**	**TDD (m)**	**S_w.(m^3/day/m)**
1	AK1	48.2	48.1	0.1	0.79	96.50	68.25
2	AK2	59.1	58.9	0.2	0.93	151.1	80.35
3	AK3	42.7	42.6	0.1	0.84	142.1	72.57
4	AK4	49.3	49.2	0.1	0.49	158.9	42.33
5	AK5	61.3	61.2	0.1	0.59	83.50	50.97
6	AK6	57.4	57.3	0.1	0.77	164.1	66.52
7	AK7	49.1	48.9	0.2	0.81	141.8	69.98
8	AK8	47.2	47.1	0.1	0.82	115.3	70.84
9	AK9	52.3	52.2	0.1	0.77	144.1	66.52

T. DEPTH= Total depth, I. DEPTH= Installation depth, S_w= Specific capacity, DWS= Dead Water Stock, TDD= Total Drawdown

Moreover, across the investigated wells, DWS ie DWZ recorded a value that ranges between 0.1-0.2 meters. As earlier explained these values represent the water column zone in each well where maximum pumping exercise cannot produce and this is due to difference in the total recorded depth and installation depths of the borehole. Specific capacity of the wells ranges between 42.33-80.35m^3/day/m in Akerebiata wells (Table 2). The water column trapped in the borehole will help prevent sucking of fine grain sand and mud particles into the submersible pump, ensure purity of the underground water and ensure the long span performance of the pump. In AK2 borehole, 55.3m TDD was recorded with only 0.2m left as dead water stock (DWS) in the well. This is better as the chance of infiltration of fine grained particles of mud and sand into the submersible pump is low.

Static and Dynamic water levels of Tanke Wells

Tanke boreholes constitute the basement complex boreholes sitting on fresh and weathered granitic rocks. These boreholes were pump tested to give the estimates of the aquifer properties for better comparative analysis with the boreholes around Akerebiata area. More importantly, 10 boreholes were available for the study and SWL recorded ranges from 6.1-9.2m across the boreholes. These SWL represent the water level at rest in the column before pumping exercise. It is worthy of note that TK1, TK2, TK3 and TK4 reflect a depth analysis of 102.8, 159.1, 149.1 and 168.2m respectively. Similarly, other boreholes of TK5-TK10 were drilled to depths that ranges from 91.90-171.4m (Table 3).

Dynamic water levels (DWL) was measured as the points of equilibrium between the discharge and recharge rates while pumping was ongoing. As mentioned earlier, this represent a major fracture at these varying points that supply the wells with water and that was why there will always be a temporary standstill of the depletion rate of the water that represent the equilibrium position. Ibrahim et al (2023). TK1, TK2, TK3, TK4, TK5 all recorded a DWL of 41.9, 51.3, 48.2, 49.2 and 67.2m respectively.TK6, TK7, TK8, TK9 and TK10 all recorded 92.8, 96.2, 89.3, 78.5 and 89.3m respectively. It is crystal clear that in these wells, SWL are deeper just as the Total depths of the wells are deeper than the boreholes from the sedimentary terrain of Akerebiata area.

Yield of the Boreholes

The yield of the boreholes were measured and noticed to be close to values obtained from the Akerebiata boreholes. Evaluated boreholes yield ranges from TK1, TK2, TK3, TK4and TK5 with yield of 0.65, 0.67, 0.72, 0.55 and 0.51 liters/secs respectively. These values points to the factthat the moderate yield recorded can be traced to deeper depths, higher hydraulic conductivity and excellent transmissivity of the water to the surface, where its needed. Moreso, TK6, TK7, TK8, TK9 and TK10 recorded 0.59, 0.61, 0.62, 0.71 and 0.68 liters/sec respectively. TK7 has a total pumping time of 322 liters per minute, while its recharge was 18.6 liters per minute.

Table 3; *Aquifer properties of Tanke boreholes*

Borehole codes	**Depth (m)**	**SWL (m)**	**TPT (secs)**	**DWL (m)**	**Yield (L/sec)**	**TDD (m)**	**TRT (sec)**	**RDD (m)**
TK1	102.8	6.1	17633	41.9	0.65	96.50	1237	0.14
TK2	159.1	7.9	18236	51.3	0.67	151.1	1267	0.18
TK3	149.1	6.8	17650	48.2	0.72	142.1	1154	0.13
TK4	168.2	9.2	18349	49.2	0.55	158.9	1098	0.18
TK5	91.90	8.2	18938	67.2	0.51	83.50	1472	0.09
TK6	171.4	7.2	18133	92.8	0.59	164.1	1178	0.09
TK7	149.1	7.1	19371	96.2	0.61	141.8	1165	0.11
TK8	147.1	8.9	17991	89.3	0.62	132.1	1090	0.18
TK9	122.1	6.7	18201	78.5	0.71	115.3	1143	0.11
TK10	151.3	7.1	17691	89.3	0.68	144.1	1137	0.14

SWL= Static Water Level, TPT= Total Pumping Time, DWL= Dynamic Water Level, TDD= Total Drawdown, TRT= Total Recharge ie recovery Time, RDD= Residual Drawdown and DWS= Dead Water Stock

Total Drawdown of the Boreholes

As earlier explained drawdown in these wells represent total depleted water column of the borehole from the SWL to the base of cone of depression created during pumping exercise. The investigated basement terrain boreholes of Tanke area showed a remarkable drawdown within an extended period of time that varied between 17633 to 19371 seconds and that can be interpreted to be set of good boreholes that ranges from 293 to 322 minutes of pumping. For record purpose, TK1 had a 96.50m TDD, TK2, TK3, TK4 all recorded 151.1, 142.1 and 158.9m TDD respectively. TK5, TK6, TK7 and TK8 all recorded 83.5, 164.10, 141.8 and 132.1m of TDD respectively, while TK9 and TK10 had 115.3 and 144.1m. The column of depleted water levels in these wells are so high to be achieved within tabulated time intervals with TK4 having the highest TDD of 158.9m for just 18349 seconds which is equivalent to 305 liter per minute. In essence, the spontaneous excellent recharge makes the well a highly prolific one for underground water production that can be used for extensive irrigation of farmland and industrial purpose. TRT varied from the highest 1472 seconds equivalent to 24 minutes (TK2 well) to the lowest 1090 seconds equivalent to 18 minutes TRT for TK8 well. The recharge i.e. recovery rate is very fast.

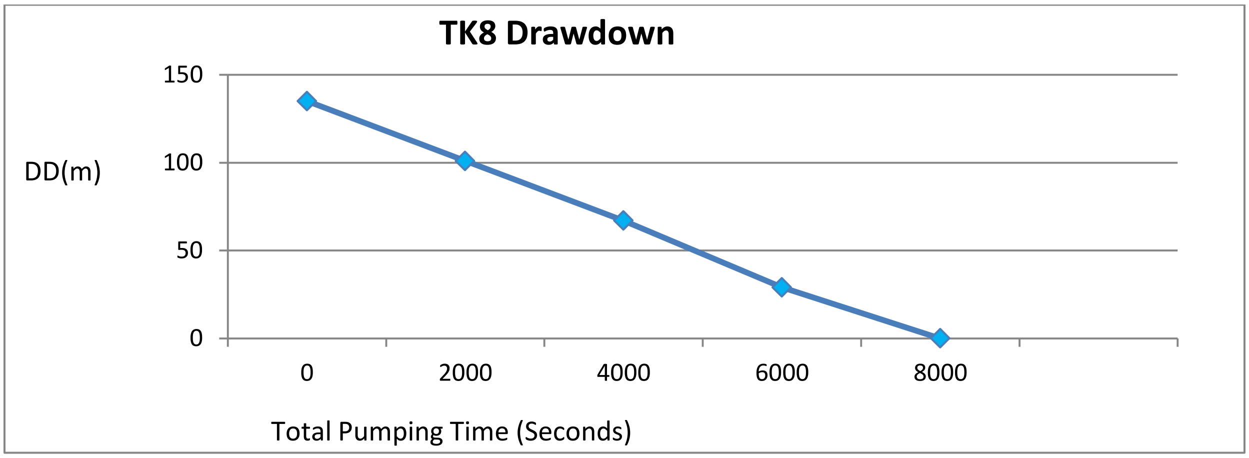

Fig.5: Drawdown graph of TK8 Borehole

The recorded RDD of the investigated wells is commonly a function of how good a borehole can recover to its original point or even pass the original SWL as it recharges and possibly at what time interval this can be done. In these boreholes, residual DD varied from 0.09 to 0.18m with the highest recorded RDD being TK2 and TK8 of 0.18m, while TK5 and 6 recorded the least of 0.09m.

Specific Capacity and Dead Water Stock of Tanke Wells

Furthermore, across the investigated Tanke wells, DWS ie DWZ ranges between 0.1- 0.3 meters. As earlier explained, these values represent the water column zone in each well where maximum pumping exercise cannot produce and this is due to difference in the total recorded depth and installation depths of the borehole. Specific capacity of the wells ranges between 62.20 - 44.06m^3/day/m. (Table 4).

Table 4: *Specific capacity and Dead Water Zone ie stock of Tanke wells*

S/N	BHC	T. DEPTH (m)	I. DEPTH (m)	DWS (m)	YIELD (l/s)	TDD (m)	S_{w}.(m^3/day/m)
1	TK1	102.8	102.6	0.3	0.65	96.50	56.16
2	TK2	159.1	159.0	0.1	0.67	151.1	56.88
3	TK3	149.1	148.8	0.3	0.72	142.1	62.20
4	TK4	168.2	168.0	0.2	0.55	158.9	47.52
5	TK5	91.90	91.70	0.2	0.51	83.50	44.06
6	TK6	171.4	171.4	0.1	0.59	164.1	50.97
7	TK7	149.1	148.9	0.2	0.61	141.8	52.70
8	TK8	147.1	146.9	0.2	0.62	132.1	53.56
9	TK9	122.1	121.8	0.3	0.71	115.3	61.34

T. DEPTH= Total depth, I. DEPTH= Installation depth, S_w= Specific capacity, DWS= Dead Water Stock, TDD= Total Drawdown.

Comparative Analysis

The Akerebiata wells recorded shallower depths that ranges in value to be between 42.7-61.3mm than the Tanke boreholes that vary between 91.70 to 171.4 m, but their water production capacities in terms of the recorded yield ranges between 0.59-0.98 L/seconds compared to Tanke boreholes that recorded 0.51-0.72m.

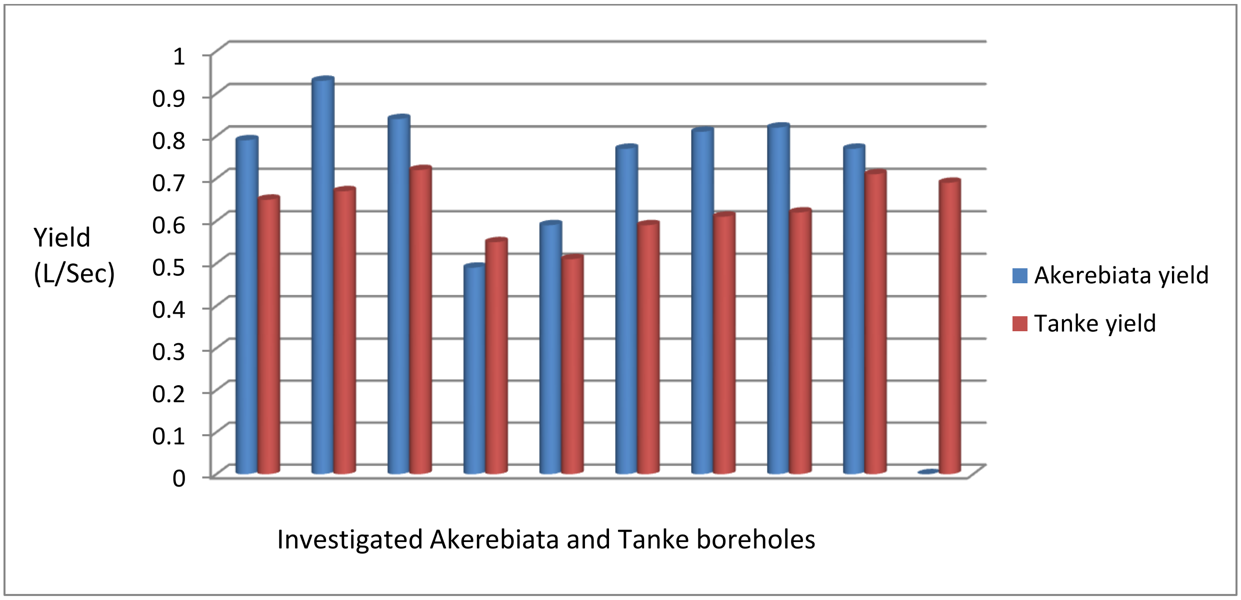

Fig. 6: Comparative yield of Akerebiata and Tanke wells

The Dead Water Zone of the wells refer to the column of water in the wells of the borehole where maximum amount of pumping exercise cannot produce the water to the surface for use. Ibrahim et al (2023). This stock of water in the wells of Akerebiata and Tanke varied and are commonly defined by the recorded difference in installation and borehole depths in the two areas. DWS of Akerebiata varied around 0.1-0.2 meters, while that of Tanke boreholes varied between 0.1-0.3meters. There is an increasing trend in linking geophysical survey with groundwater production, Olaniyan et al (2008 and 2010). However, I find such practice highly faulty, because no geophysical survey technique has the capacity to quantify the performance of an aquifer in any geologic terrain. Ibrahim et al (2023).

Boreholes in sedimentary terrain of Akerebiata area will always have faster sedimentation rate of fine particles like sandstone, mud, claystone, limestone etc that build up within shorter time than basement complex terrain with common rock types that include granite, pegmatite, basalt, fractured and weathered rocks etc in the well. Ibrahim et al (2023). The leaching of the mineral components of the rock types is due to the close contact of the rocks and the borehole water and is known to be higher in sedimentary rocks than in basement complex terrains. Previous work experience part of which is contained here (Table 5) has revealed faster sedimentation rates such that within 4-6 years of installed boreholes with just 0.1-0.3 DWS, their accommodation DWZ space are quickly filled-up with fine particles that impacts the quality of underground water, thereby reducing the efficiency of submersible pumps and contributing much impurities to the underground water production. Detail of this will be contained in a book under preparation for publication soon.

Table 5: *Comparative analysis of DWS in sedimentary and basement complex terrains*.

S/N	BOREHOLE LOCATIONS	VARYING DEPTHS(m)	MONTHS@YEAR DRILLED	EXISTING DWS(m)	PROPOSED DWS(m) Ibrahim et al (2023)
			SEDIMENTARY TERRAIN		
1	AGBEDE	71-77	Nov, 2013	0.3-0.5	
2	OJAGBORO	49-52	Feb, 2017	0.4-0.5	0.8-1.3
3	HARMONY	39-41	May, 2018	0.3-0.4	
4	ORISUMIBARE	37-42	December 2019	0.2-0.3	
5	SHAO	41-48	December, 2015	0.2-0.3	
6	ORIRE	55-59	June, 2017	0.4-0.5	
7	OLALEMI OFFA	33-61	February, 2020	0.3-0.5	
			BASEMENT COMPLEX TERRAIN		
1	BASIN ROAD	103-115	March, 2018	0.3-0.6	
2	OTUTU, ADAVI	93-103	April, 2018	0.3-0.4	0.6-1.0
3	LADUBA	89-92	July, 2020	0.3-0.6	
4	BEKADIMS	138-149	August, 2014	0.4-0.7	
5	NSE OFFICE, ILORIN	133-148	December, 2020	0.3-0.7	
6	MICHEAL IMODU	107-102	February 2019	0.4-0.6	

DWS= Dead Water Stock ie Zone.

Furthermore, with this recommended of 0.8-1.3 meters as DWS in all sedimentary terrain, then the wells will be able to last minimum of 10 years before a new well development can be initiated for removal of impurities, but this is in the absence of other technical issues that may affect the performance of the borehole. Similarly, a proposal of 0.6-1.0 meters as DWS in all basement complex terrain will allow a minimum of 10 years smooth performance before a new well development can be initiated for removal of impurities associated by accumulation of sediments in the well. In essence, sedimentation rates is often slower in basement complex e.gTanke wells than sedimentary terrain like Akerebiata boreholes.

Specific capacity of the investigated boreholes have all shown that among the Akerebiata wells, AK4 recorded the lowest which is 42.33m^3/day/m toAK2 (highest specific capacity) which is 80.32 m^3/day/m. More importantly, among Tanke wells, TK5 recorded 44.06m^3/day/m as the lowest while TK3 recorded the highest with 62.20 m^3/day/m. In essence, with maximum pumping rate, the drop in water level in each well as evidenced by the expansion in the cone of depression. The two terrains of Akerebiata and Tanke wells have shown good specific capacities with the recorded values associated with good porosity, permeability, hydraulic conductivity and excellent transmissivity of the water from the aquifer to the wells, but despite shallow depths of Akerebiata wells, they are still better in water production capacity than that of Tanke wells with deeper depths of the wells. Ale et al 2015 never put into consideration the duration of pumping or recharge ie TPT and TRT, but classified boreholes performance based on just the yield. I feel its not enough to categorize the performance of wells based on yield alone, but combination of other factors like TRT and TPT.

Conclusions and recommendations

The study has revealed Akerebiata sedimentary wells have SWL with 2.8-5.9m, DWL recorded 18.1-28.2m, yield varied between 0.49-0.93L/Sec, RDD was measured to be 0.01-0.09m. Specific capacity was measured to be 42.33-80.35m^3/day/m while DWS recorded 0.1-0.2m. Conversely, Tanke wells were pump tested and revealed SWL varied between 6.1 and 8.9m, DWL recorded 48.2-96.2m, yield varied between 0.51-0.72L/Sec, RDD was measured to be 0.09-0.18m. Specific capacity was calculated to range from 44.06 to 61.34m^3/day/m. DWS recorded for Tanke wells ranges from 0.1 to 0.3m. The comparative assessment of the two group of wells ie Akerebiata wells have shown better water production capacities despite their shallow depth of occurrence, while the deeper boreholes of Tanke wells have shown average water production capacities. Recommendation of 0.8-1.3 meters as DWS in all sedimentary terrain will allow such wells to last minimum of 10 years before a new well development can be initiated for removal of sediment impurities, but this is in the absence of other technical issues that may affect the performance of the borehole.

Similarly, a proposal of 0.6-1.0 meters as DWS in this and all basement complex terrain will allow a minimum of 10 years smooth performance before a new well development can be initiated for removal of impurities associated by accumulation of sediments in the well. Finally, the content of the manuscript is a practical manifestation of what is obtainable onsite, not theoretically based and to enhance better practical understanding for young Geoscientists. A book is under preparation to give better and greater insight to this. Finally, DWS is hereby proposed to be included in Hydrogeological/Geological dictionary of our time.

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