JEAS

JOURNAL OF ENGINEERING AND APPLIED SCIENCES

Journal of Engineering and Applied Sciences 10 (2014), 65 - 80

Impacts of septic tank systems on ground water quality in high water table terrain: A case study of Lokoja

[1]Oguche O. Daniel, [2]Ekenta E.O., [3]Anyata B.U

[1]State Ministry of Works and Housing, Lokoja, Kogi State.
[2]Deparmentt of Civil Engineering, Nnamdi Azikiwe University Awka.
[3]Departmentt of Civil Engineering University of Benin

Abstract

This research examined the impacts of septic tank systems on ground water quality in high water table terrain using Lokoja as a case study. Eight shallow wells were chosen (four from each area) from two areas of Lokoja namely Adankolo and Gadumo. The distances of the wells from the septic tanks as well as their depths were measured. Water samples were collected from these wells and were subjected to physical, chemical and bacteriological analysis using series of apparatus and reagents and standard quantitative method for bacteriological examinations. Physical parameters including colour, turbidity, electrical conductivity, total dissolved solids (TDS) and pH were analysed as well as chemical parameters including nitrate, calcium, chloride, total hardness, total alkalinity, dissolved oxygen and phosphate. Bacteriological test included coliform count and E-coli count. The results were compared with World Health Organization (WHO) and National Agency for Food, Drugs Administration and Control (NAFDAC) Standards. Correlation and regression as well as analysis of variance (ANOVA) were used to determine if relationship exist between the parameters and distances of wells from septic tanks, the strength of the relationship and if significant difference exist between parameters and distance and between parameters from the two areas. It was noted that siting septic systems near or very close to shallow wells have adverse effects on the water quality from these shallow wells because almost all the physical and chemical parameters were higher than WHO guide level standard recommended for drinking water as they correlated with distance. The viable coliform count per 100ml for the well points (samples) also was above WHO limits. This could lead to water borne disease. There was correlation between parameters and distance in some samples, in some others there was significant difference and the samples from the two areas (Adankolo and Gadumo) are the same.

Key words: ground water, high water table, shallow wells, septic tank, water quality.

1. Introduction

Water, air, food and shelter are the essential items for any living being. Without air one can not survive or live even for few minutes. It is possible to survive without food and shelter for some days but not without water, it is not possible to survive for much of the time. Among the necessities of life, water is next to air in order of its importance. (Rhoads and Tanner, 2003). Water is also important to all biological life as 65% of body fluid of the human being is water. Water has unique position among other natural resources like minerals, fuels, forest, livestock etc because a country can survive in the absence of any other resource except water. Water can be put to various use due to its unique properties.

There is a clear correlation between access to safe water and GDP per capita (US EPA 1996, 1998). However some observers have estimated that by 2025 more than half of the world's population will be facing water-based vulnerability (Kulshreshtha, 1998).

Water like air, not only survives life on our planet but also provides us comfort and luxuries owing to its numerous uses. Among its many functions are to supply physical needs, preserve body cleanliness, ensure the cleanliness of the municipal environment, furnish a means of fire protection and meet the needs of the industry.

Rain is the chief or preliminary source of all water. Other sources could be surface and ground sources. Ground water is the water that occurs in the saturated zone of variable thickness and depth below the earth's surface. The rainfall that percolates below the ground surface passes through the voids of the rocks and joins the water table formed by cracks and pores in the existing rocks and unconsolidated crystal layers to make up large underground reservoir where part of the precipitation is stored (Garg, 2007.)

The use of open wells is a traditional method of tapping ground water where ground water table is high. From sanitary point of view, wells furnish safe drinking water than what could be obtained from surface water source.

In Nigeria, there is the challenge of lack of supply of pipe borne water, hence many homes have wells sited around the houses at a close distance from septic tank. 52% of Nigerians do not have access to improved drinking water supply and sanitation (Orebiyi et al, 2010). This is the situation in many parts of Nigeria and several other African countries (Adelekan 2010). Safe drinking water remains inaccessible for about 1.1 billion people in the world (Mintz et al, 2001). Those most susceptible to water borne desease are children, the elderly, pregnant woman, and inmunocompromised individual, making water-borne disease one of the five leading causes of death among children under the age five (Gerba et al 1996). In 1967, the world Health Organization (WHO) reported that 40% of the deaths in developing nations occur due to infections from water related diseases and an estimated 500 Million cases of diarrhea, occurs every year in children below five years in parts of Asia, Africa and Latin America (Adejuwon and Mbuk 2011).

The looming water crisis is becoming a major issue on the world agenda for the twenty-first century. The world water council presented the World water vision during the second World water forum and ministerial conference at the Hague in March 2000 (Cosgroved and Rijsberman 2000) as reported by (Zaporoec 2002). The Vision document emanating from the conference reported that 1.2 billion people or one-fifth of the world population, do not have access to safe drinking water, while half of the world population lack adequate sanitation. The vision statement further stated that rapidly growing cities like ours, burgeoining industries and rapidly rising use of chemicals in agriculture and other factors have undermined the quality of rivers, lakes and aquifers.

In many urban areas like Kaduna disposal of liquid waste, by septic tank, Cesspits and laterines is still practiced (Olaniyan, Ogwuche and Olorunaiye 2012).

The discharge of human waste more or less directly from laterines into pits is still common in many parts of the world. Poorly functioning septic tanks

in the ground may over flow and discharge nitrogen-rich liquids into the unsaturated zone (Olaniyan et al 2009).

Accessibility, affordability and sustainability of this scarce resource lead to this study.

2.0 The Study Area.

2.1 Description of Study Area

The study areas are Adankolo and Gadumo areas of Lokoja, Kogi State.

These areas are occasionally flooded when there is a heavy rainfall.

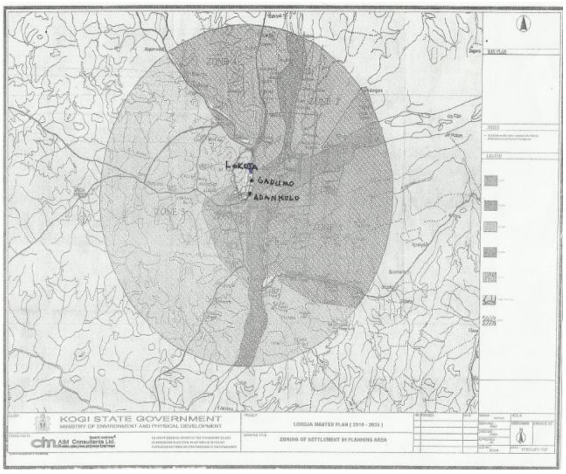

Fig. 2.1 Map of Lokoja showing Adankolo and Gadumo areas.

During the raining season, the water table rises to the extent that water gushes out in street earth drains, from under the building foundations and hand dug wells.

Settlements in Adonkolo and Gadumo areas are clustered. The buildings are very close to each other with no marked streets and this arrangement favours flooding. The setlements in some of these places are extended family settlements with the fathers, mothers, sons and uncles living together.

2.2 **Geographical Location**

Lokoja lies proximately on Latitude 7 degree, 48 minutes and 5 seconds north (07^0 48^1 05^{11} N) and longitude 6 degree, 44 minutes and 39 seconds east (6^0 44^1 39^{11} E) Lokoja is well connected and accessible through state and federal high ways and is the gateway and transit point between the northern, eastern and southern parts of the country.

Seasons and Durations

Lokoja enjoys a climate of the middle

Fig. 2.2 Close-knited (clustered) settlements in Adakolo

belt-zone with two seasons, rainy and dry seasons. The rainy season lasts between 190-200 days with mean annual rain fall of about 1340mm with September recording the highest rain (Meteorological Department Lokoja).

Temperature

The mean monthly temperature is highest in March at 30.5 degrees Celsius and lowest in August at 23 degrees Celsius.

3.0 **Materials and Methods**

3.1 **Reconnaissance and Location of Sampling Points.**

A site survey was carried out on the sites under consideration, Adankolo and Gadumo areas of Lokoja so as to obtain first hand information and data for the study area. Eight wells were sampled, four in Adankolo and four in Gadumo.

Visual inspection of the selected wells and sanitary systems of the immediate environment of the wells was conducted. The well points in Adankolo where samples were taken were scattered over a radius of about 1.2km from old Adankolo to Adankolo new layout while those of Gadumo were of a radius of about 900m. Some of the wells are communal wells and some of the septic facilities are not in the same compound with the wells.

The distances of the septic facilities from the wells at each well point were recorded (between 2.7m and 18m). Equally the depth of water in the wells was taken by lowering a measuring tape into the well until the tape just touched the water surface in the well and the depth was recorded. The analyses were carried out in August and September at the peak period of the rains when water intrusion into the wells is higher. The results obtained were then compared with World Health Organization (WHO) 1984 standards for drinking water. Also comparism was carried out with NAFDAC guidelines.

Table 3.1 Distances of well points from septic facility and water depth in wells (Geo probe depth).

Well points	Distance well from septic facility (m)	Water depth in well (Geoprobe depth) (m)
Adankolo 1	6.5	2.6
Adankolo 2	2.7	0.4
Adankolo 3	6.0	1.2
Adankolo 4	18.0	2.6
Gaduma 1	7.4	1.5
Gaduma 2	3.4	0.9
Gaduma 3	10.0	2.4
Gaduma 4	15.0	3.5

Well water from hand-dug wells was required for sampling. Bucket collection was used and the samples were collected during peak period of collection by the users in order to guarantee the exact samples being used by the people.

4.0 Results, Analysis and Discussions.

4.1 Results.

The results obtained in the study were from eight samples taken from the eight sampled wells, four in Adankolo and four in Gadumo areas of Lokoja. The samples were taken twice and examined for physical, chemical and bacteriological parameters and the average (mean) results were taken. The table showing the mean test results for physical, chemical and bacteriological tests are shown in tables 3.2.

Table 3.2 mean Test Results.

		Adankolo				**Gadumo**			
	Distance (m)	6.5	2.7	6	18	7.4	3.4	10	15
Physical Properties	Colour	9.45	17.3	8.6	8.25	9.75	18.6	8.9	9.8
	Turbidity (NTU)	4.52	7.8	4.35	3.85	4.64	35.05	4.85	4
	Conductivity (µs/cm)	1050	1400	750	490	1095	1350	800	410
	TDS (mg/L)	750.92	934.98	472.02	510.5	650.48	850.57	570.85	490.65
	pH	8.1	8.3	8.1	8	8.2	8.4	8.2	8.1
Chemical Properties	Nitrate (mg/L)	35.2	55.3	41.3	31.2	39.4	52.1	34.6	43.5
	Calcium (mg/L)	142	326	180	205	139	320	185	215
	Chloride (mg/L)	235	265	255	245	225	255	247	235
	Total Hardness (mg/L)	380	430	415	420	390	425	410	416
	Total Alkalinity (mg/L)	105	120	95	110	103	115	90	104
	Dissolved Oxygen (mg/L)	8.75	8.87	6.05	7.45	8.8	8.9	6.1	7.5
	Phosphate (mg/L)	3.9	7.6	6.5	3	4.1	8	6.9	3.3
Biological Properties	Coliform Count (col/100ml)	264	304	207	226	206	321	222	150
	E-Coli Count (col/100ml)	40	62	-	-	-	109	31	-

The results obtained in physical and chemical parameters are shown graphically in bar charts showing the concentrations either below or above the recommended WHO or in some cases NAFDAC permissible levels from Figures 4.1 – 4.12.

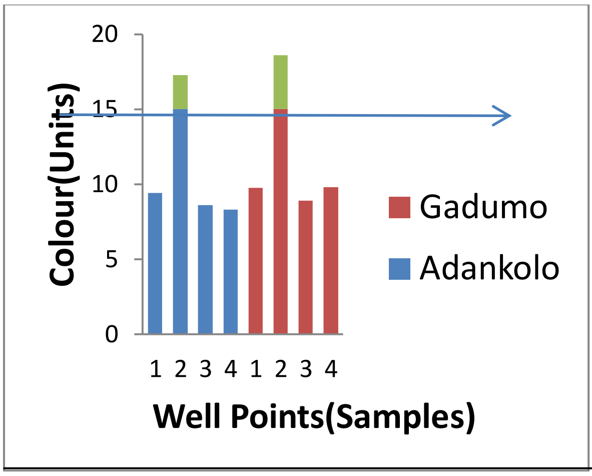

Fig. 4.1: Colour Values

WHO guide level for colour is 15 Units. For the eight samples tested for colour, samples from Well 2, Adankolo and Well 2, Gadumo have colour concentrations above the WHO required level which is objectionable.

The other six samples: Adankolo Wells 1, 3, 4 and Gadumo Wells 1, 3, and 4 have colour concentrations below the WHO guide level and are therefore acceptable.

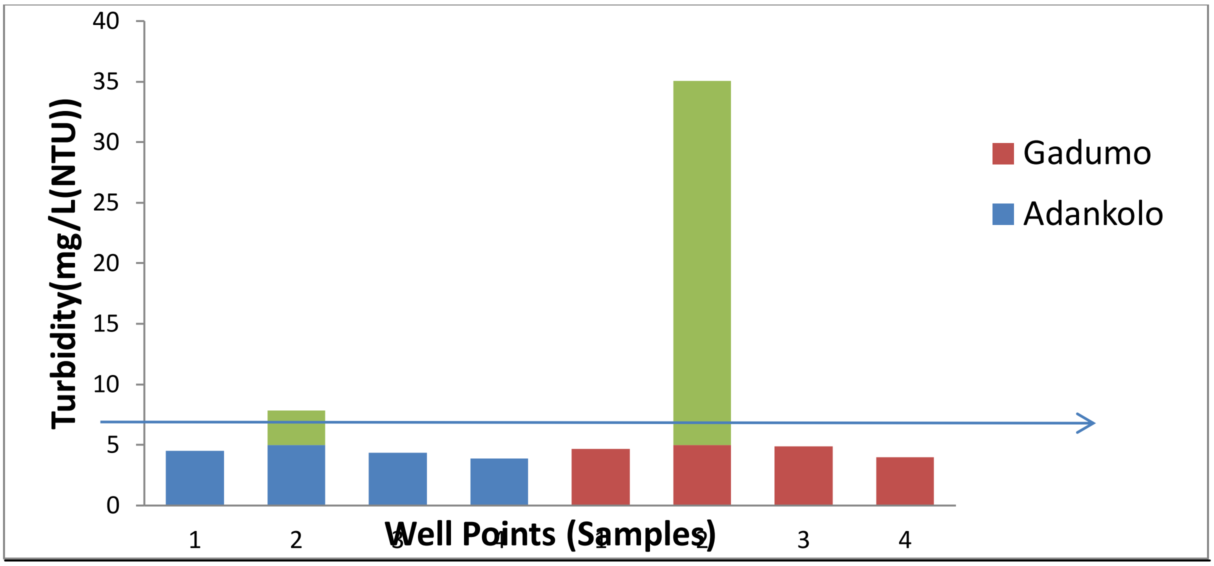

Fig. 4.2: Turbidity Values

WHO guide level for turbidity is 5 NTU Adankolo Well 2 and Gadumo Well 2 are above the WHO stipulated guide levels.

The other six samples: Adankolo Wells 1, 3, and 4 and Gadumo Wells 1, 3, and 4 are within the permissible guide level.

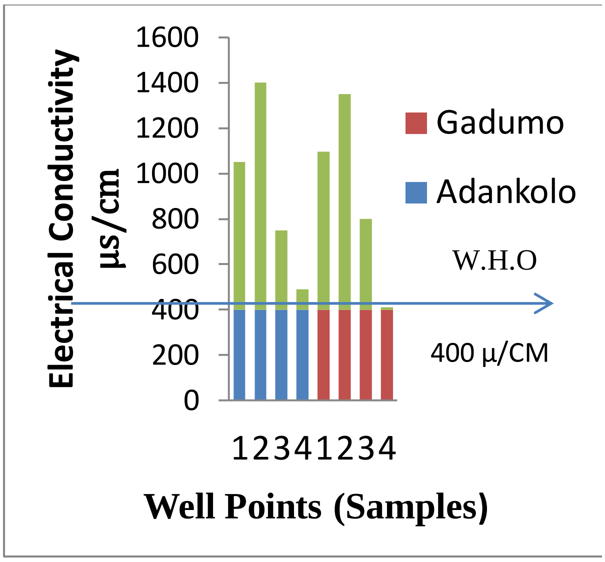

Fig 4.3: Electrical Conductivity

The WHO guide line for electrical conductivity is 400µs/cm at 25°C.

Conductivity values for all the samples are above WHO recommended level with samples Adankolo Well 2 and Gadumo Well 2 having the highest values and Adankolo Well 3 and Gadumo Well 3 having the least values.

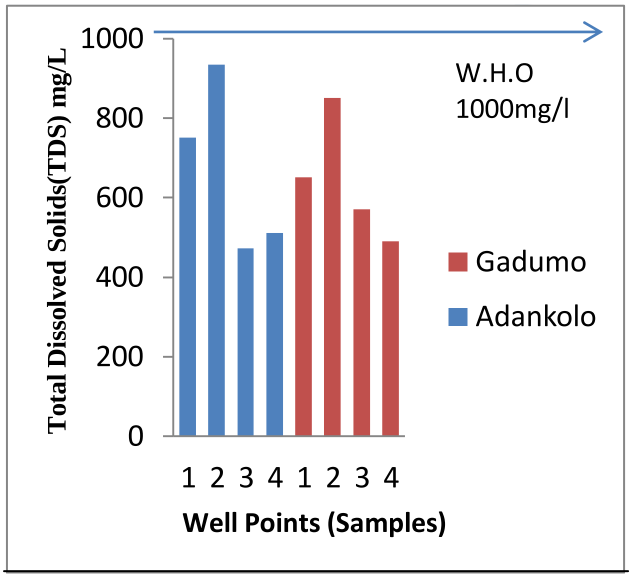

Fig. 4.4: Total Dissolved Solids.

WHO guide level for the Total Dissolved Solids is 1000mg/l. All the wells both in Adankolo and Gadumo have values below the WHO recommended permissible limit.

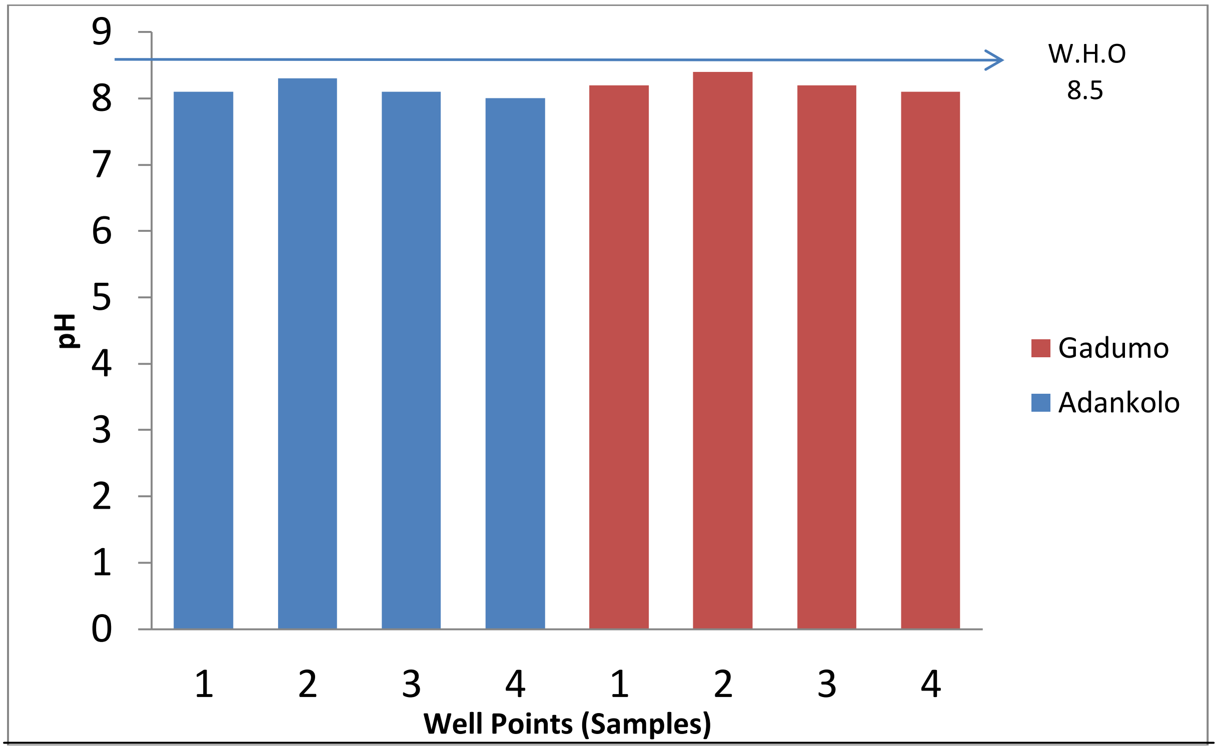

Fig. 4.5: pH Values

WHO recommended a pH of between 6.5 and 8.5. The samples in the Adankolo and Gadumo are within the recommended values.

Chemical Parameters

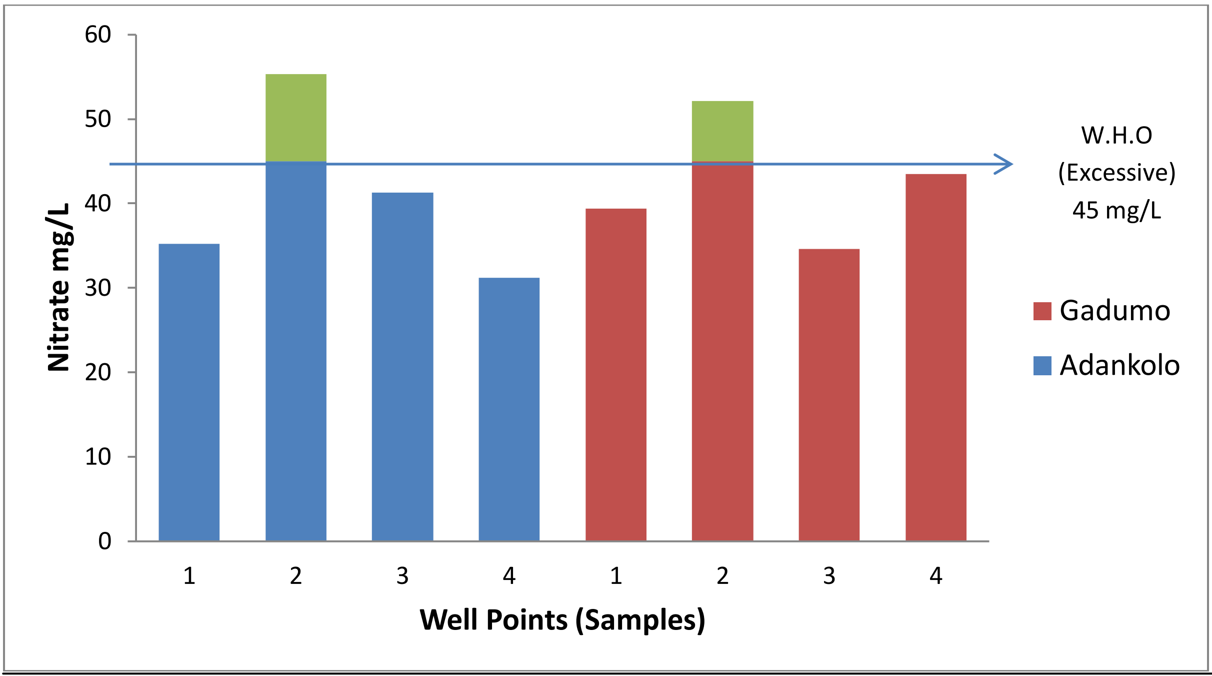

Fig. 4.6: Nitrate Values

Neither WHO nor NAFDAF specify permissible values but WHO indicated that a value of 45mg/l in water is excessive. Adankolo Well 2 and Gadumo Well 2 have excessive values.

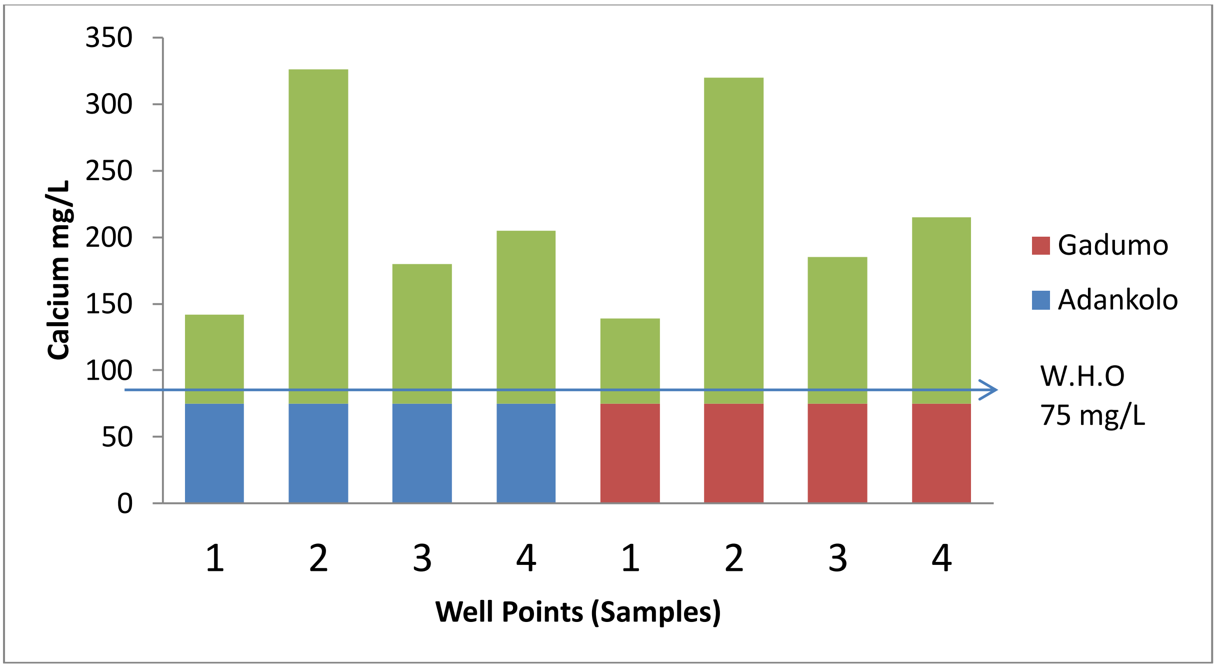

Fig. 4.7: Calcium Values

Both the WHO and NAFDAC have permissible values of 75mg/l of calcium in potable water. All the samples failed the standards as all have values above 75mg/l.

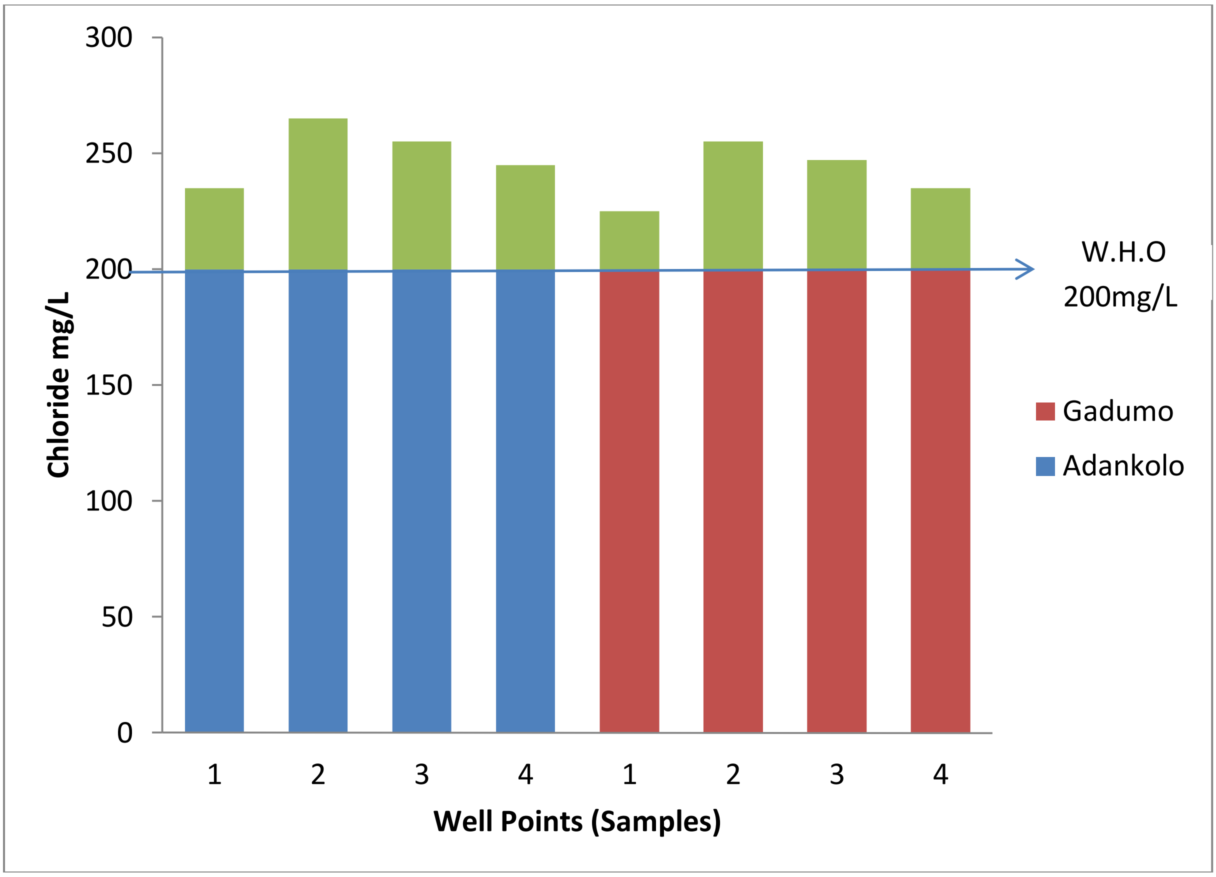

Fig. 4.8: Chloride Values
Both WHO and NAFDAC have permissible values of 200mg/l of chloride in water for domestic consumption. All the samples are above permissible values.

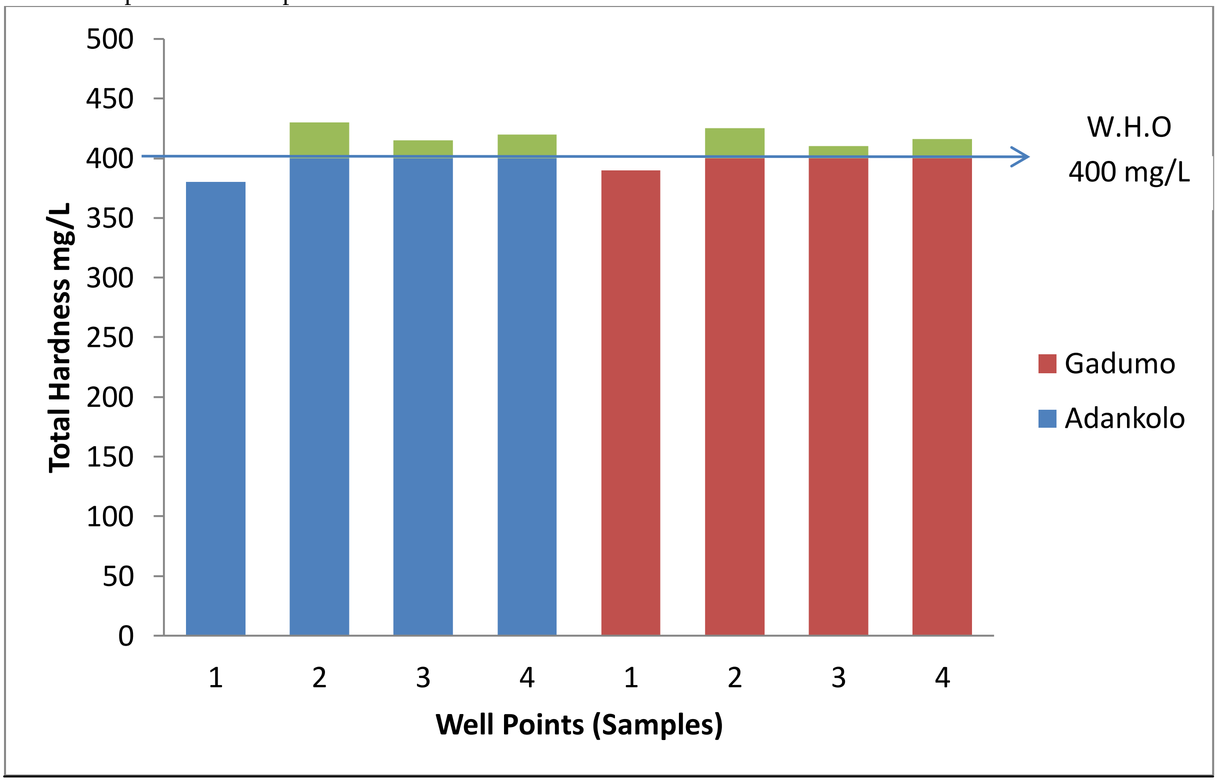

Fig. 4.9: Total Hardness
Only Wells Adankolo 1 (AD1) and Gadumo 1 (GD1) are below the WHO's recommended permissible values of 400mg/l. All other Wells in both Adankolo and Gadumo are above permissible values.

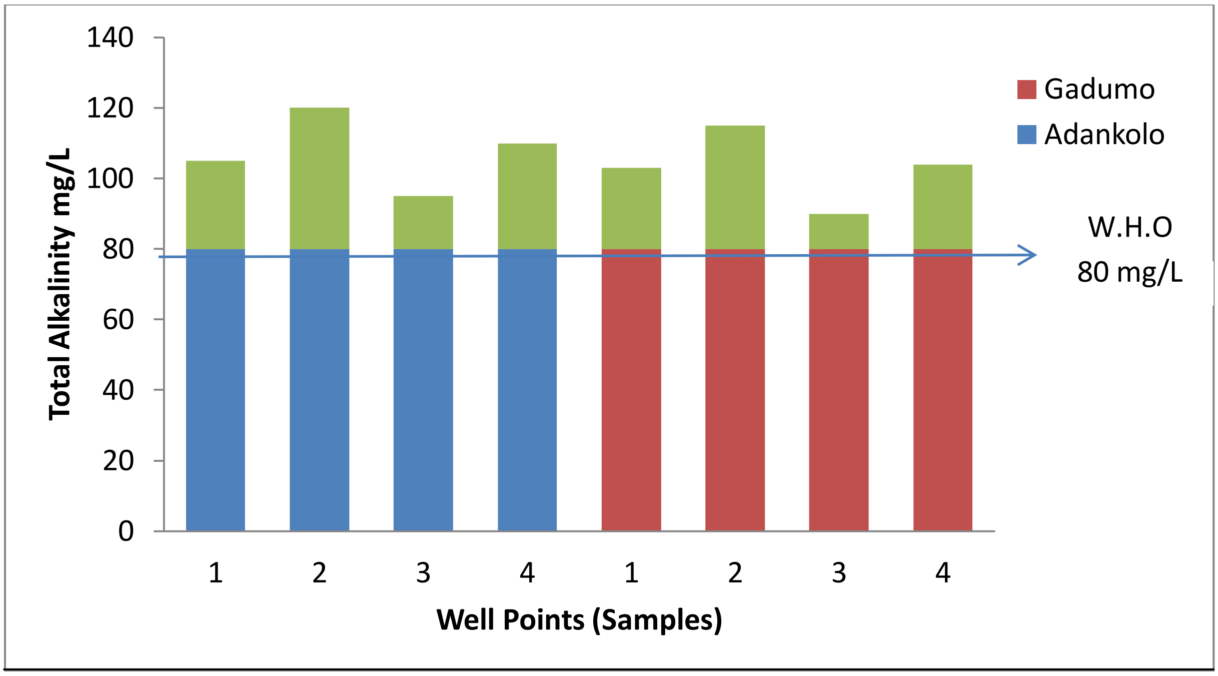

Fig.4.10: Total Alkalinity
All the water samples from both Adankolo and Gadumo have their test results above WHO permissible value of 80mg/l.

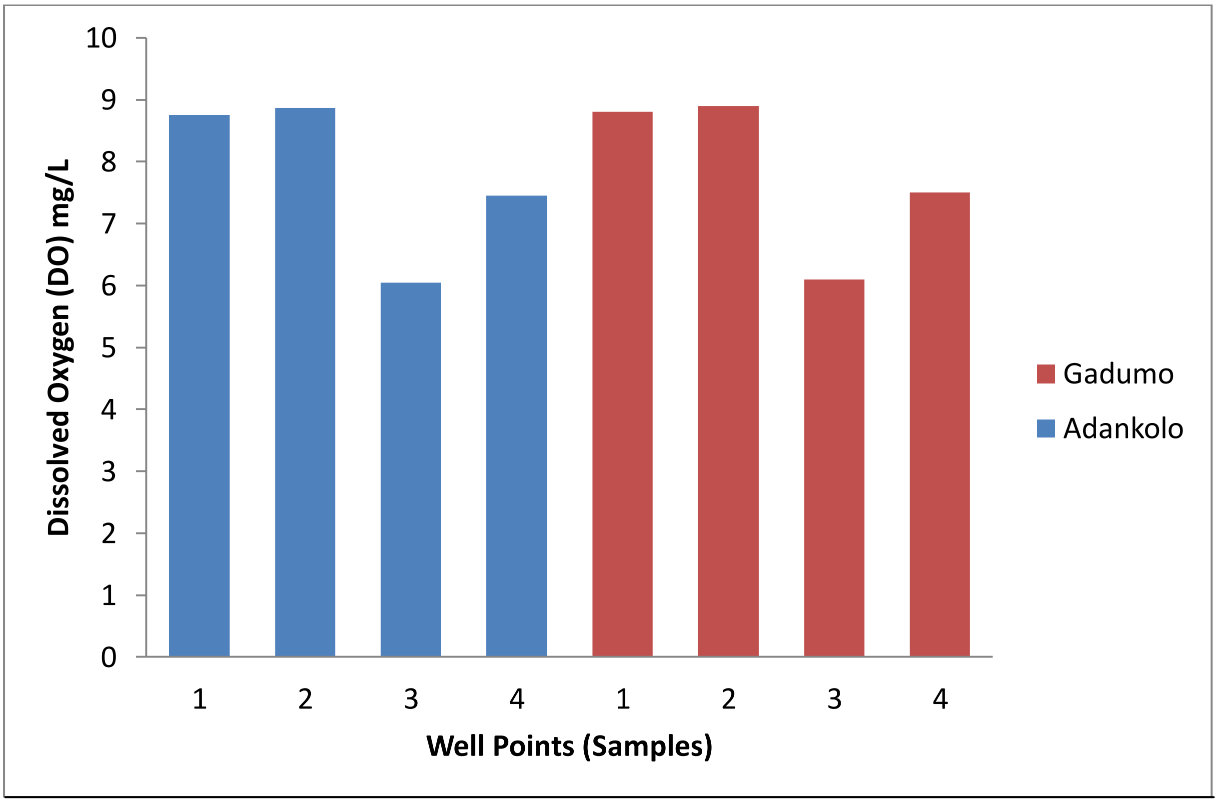

Fig. 4.11: Dissolved Oxygen Values
Both the WHO and the NAFDAC do not specify permissible limits but excess is not desirable.

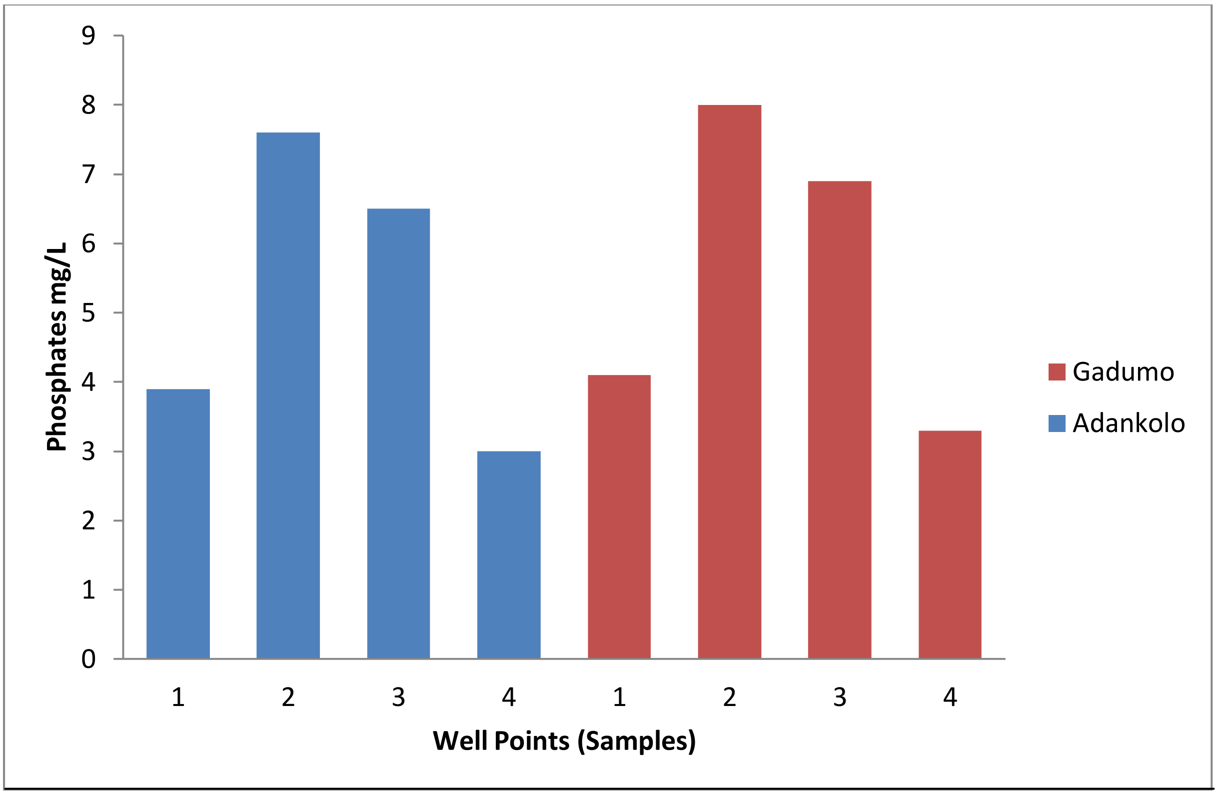

Fig. 4.12: Phosphate

Phosphate permissible values are neither indicated in WHO nor NAFDAC guidelines but excessive is undesirable.

4.2 Analysis: Regression

Regression statistics was used to identify whether relationship exists between the physical, chemical and bacteriological parameters and the distance of the wells from the septic tank/soak away pit. The strength of the relationship between the parameters and the well distances from the septic systems was measured using correlation.

Correlation was used to determine if there was relationship between parameters.

The correllation coefficient, r indicates the strength of the relationship existing between the dependent and independent parameters.

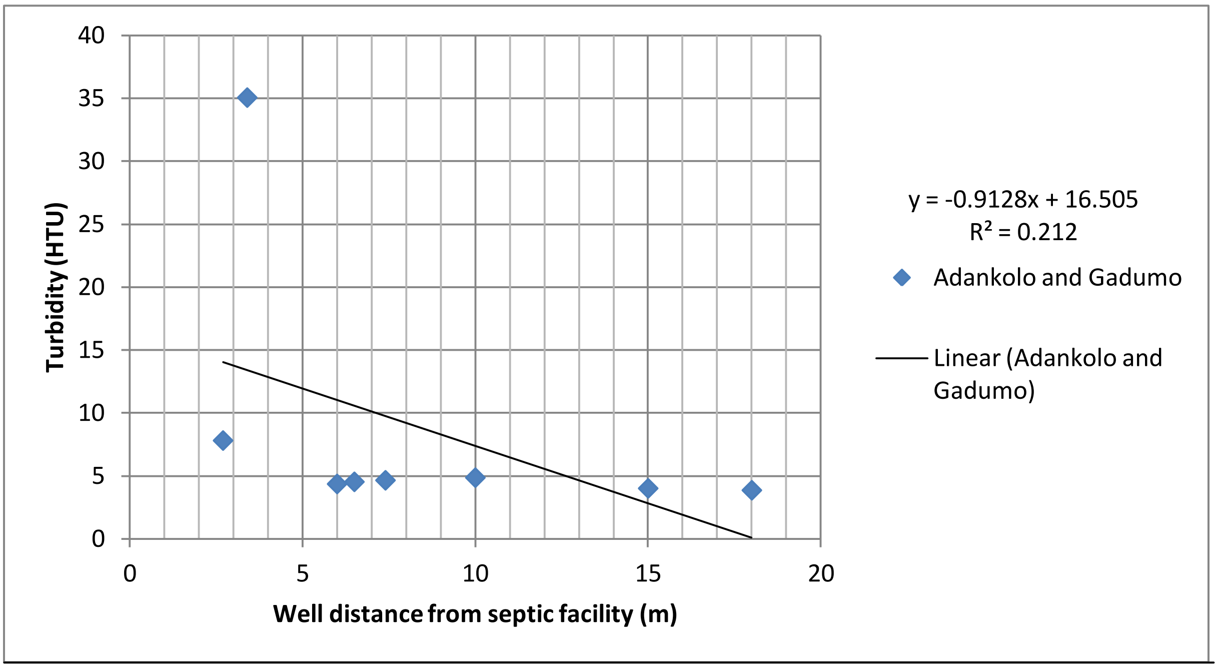

Fig 4.13: Regression of Turbidity vs. Distance

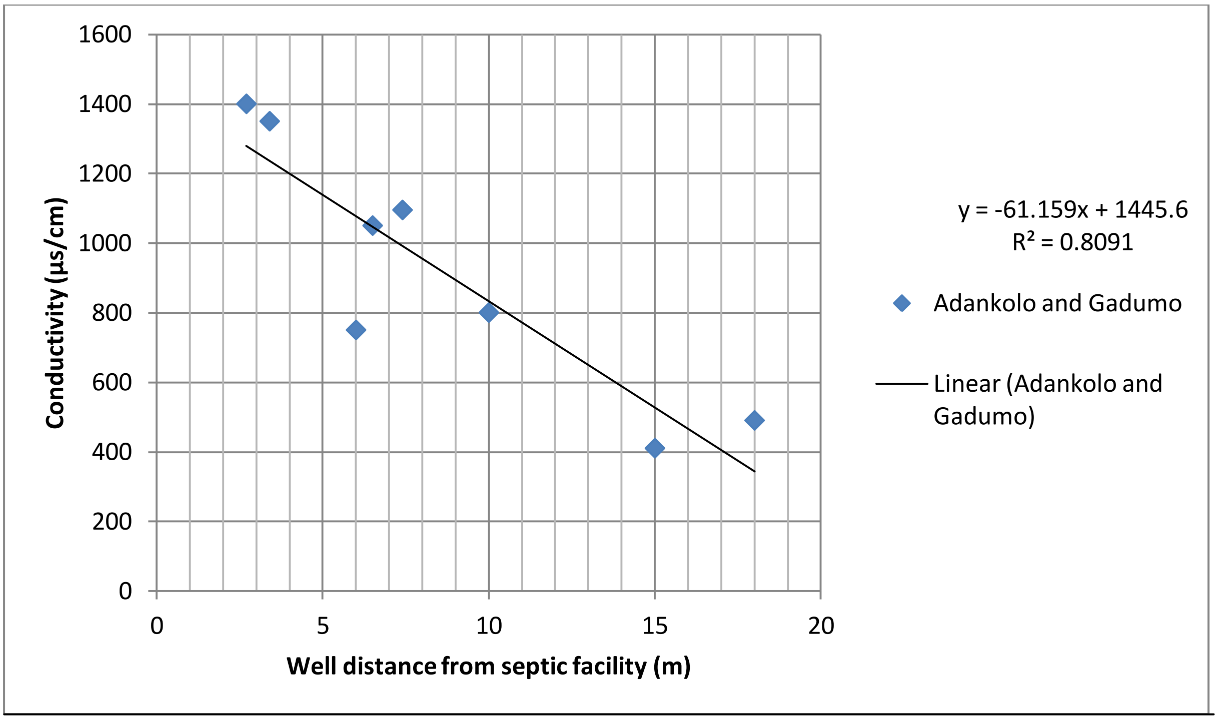

Fig. 4.14: Conductivity vs. Distance

AS Y increases, X decreases or vise-versa. An indication that the distance affects conductivity –Ref: Table 4.2

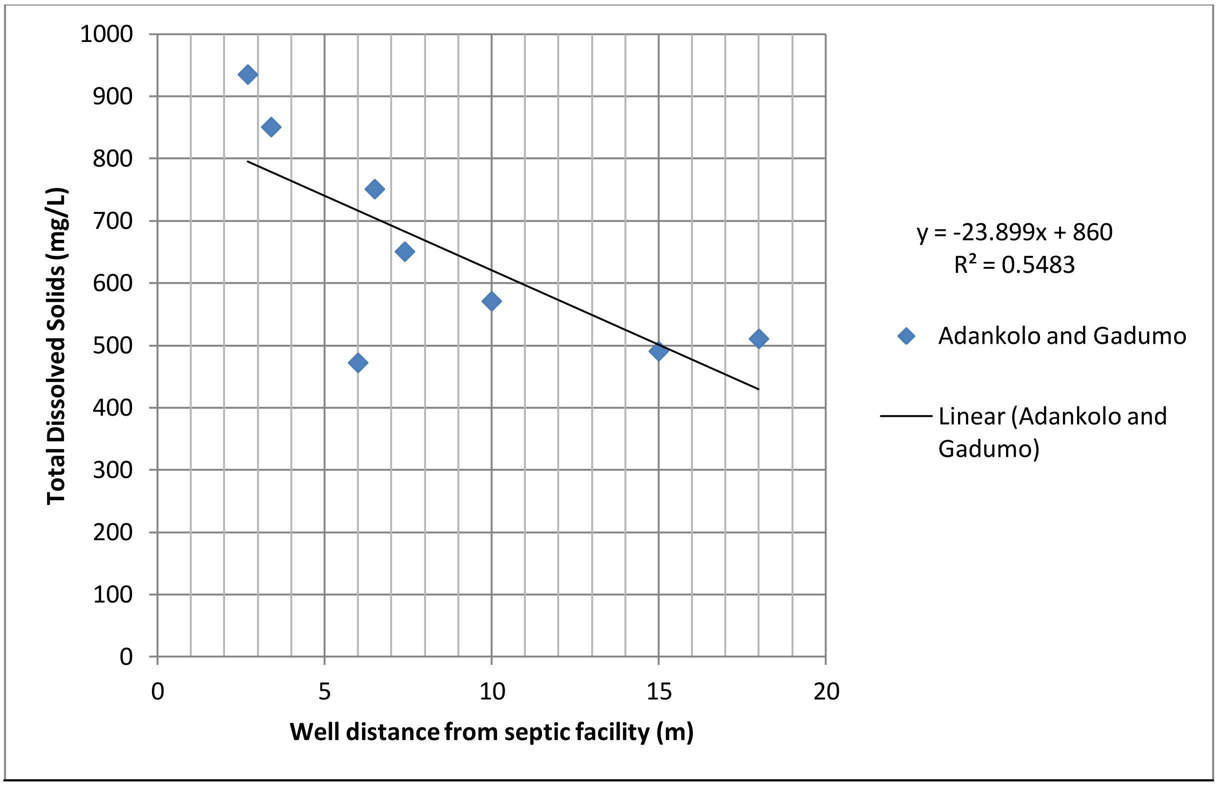

Fig. 4.15: TDS vs. Distance

As X (distance), increases, TDS decreases, which is an indication that distances affect TDS. This is same in table 4.2 where the value of r = 0.740.

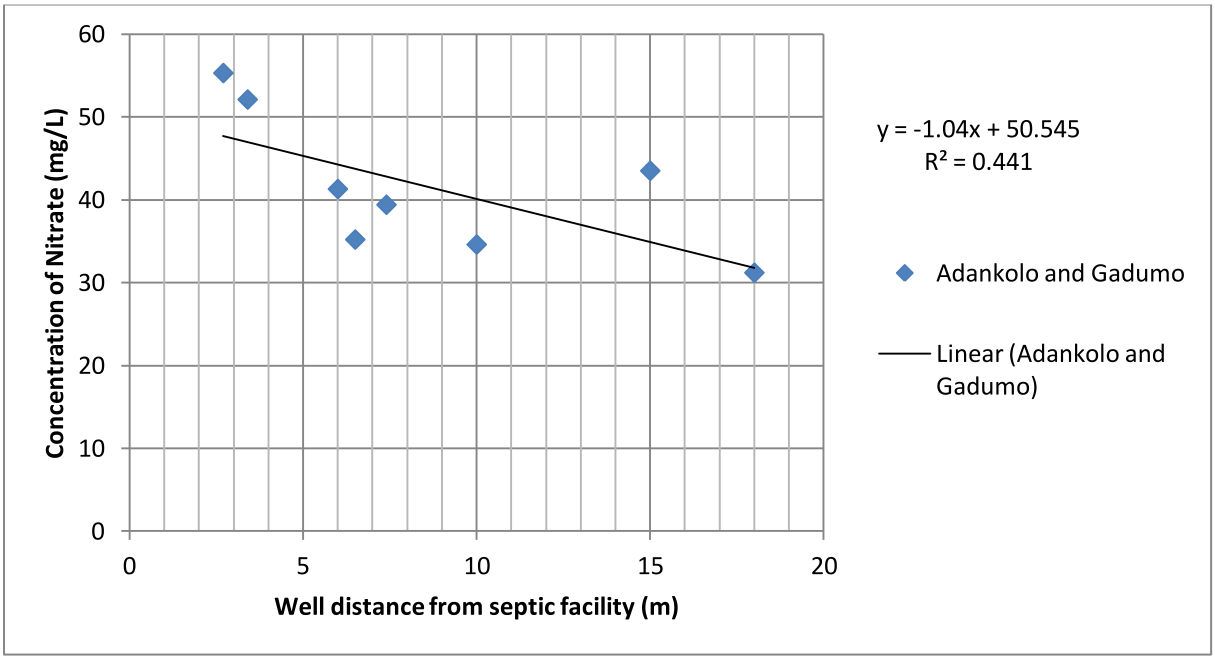

Fig 4.16: Nitrate vs. Distance

Distance equally had effect on the concentration of Nitrate in Table 4.2, r =0.843 and r^2 = 71%.

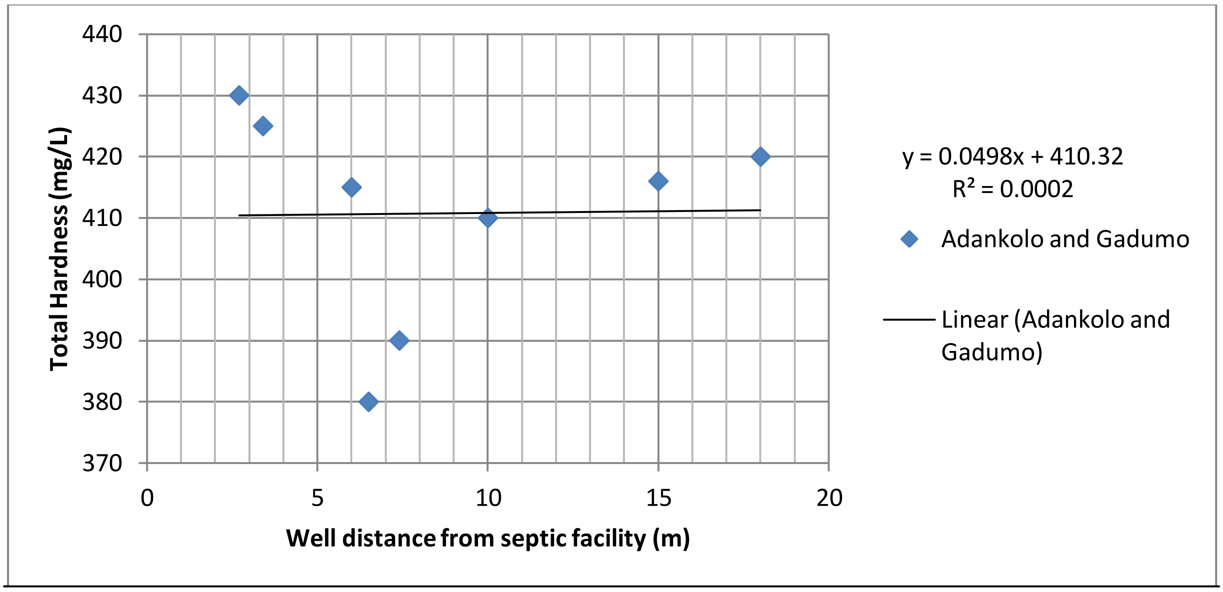

Fig 4.17: Total Hardness vs. Distance

There was a zero correlation between the variables. This is true of table 4.2 where the correlation is 0.015.

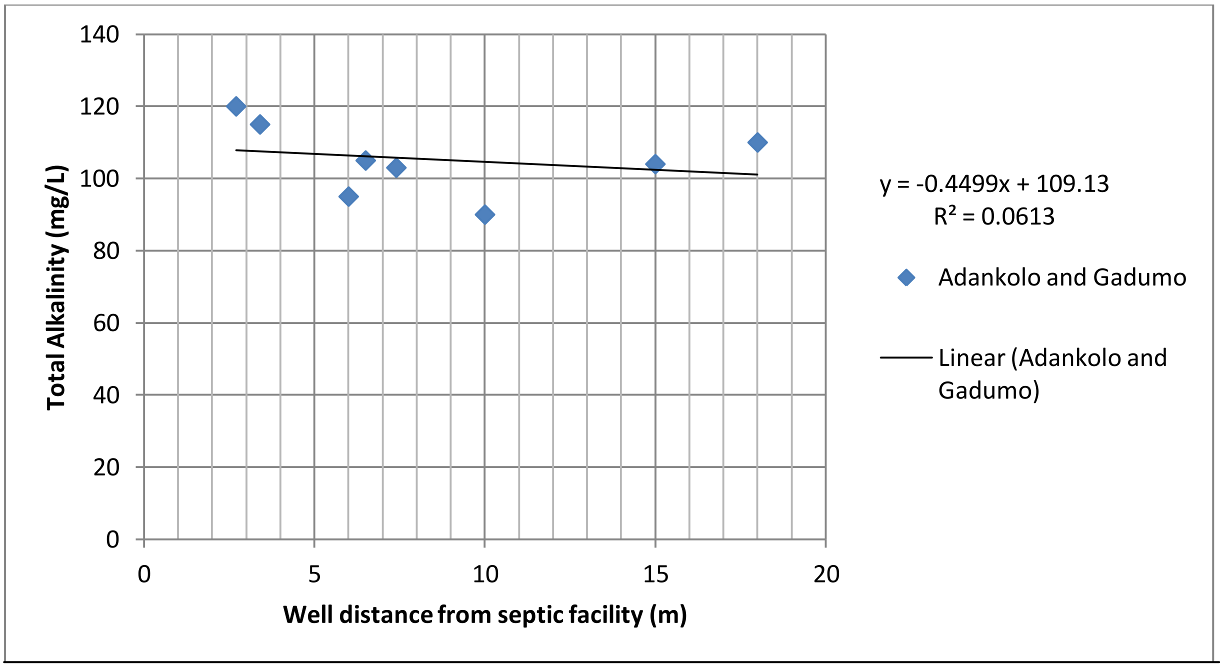

Fig 4.18: Total Alkalinity vs. Distance

Very low correlation as can be seen from the graph as is true of Table 4.2.

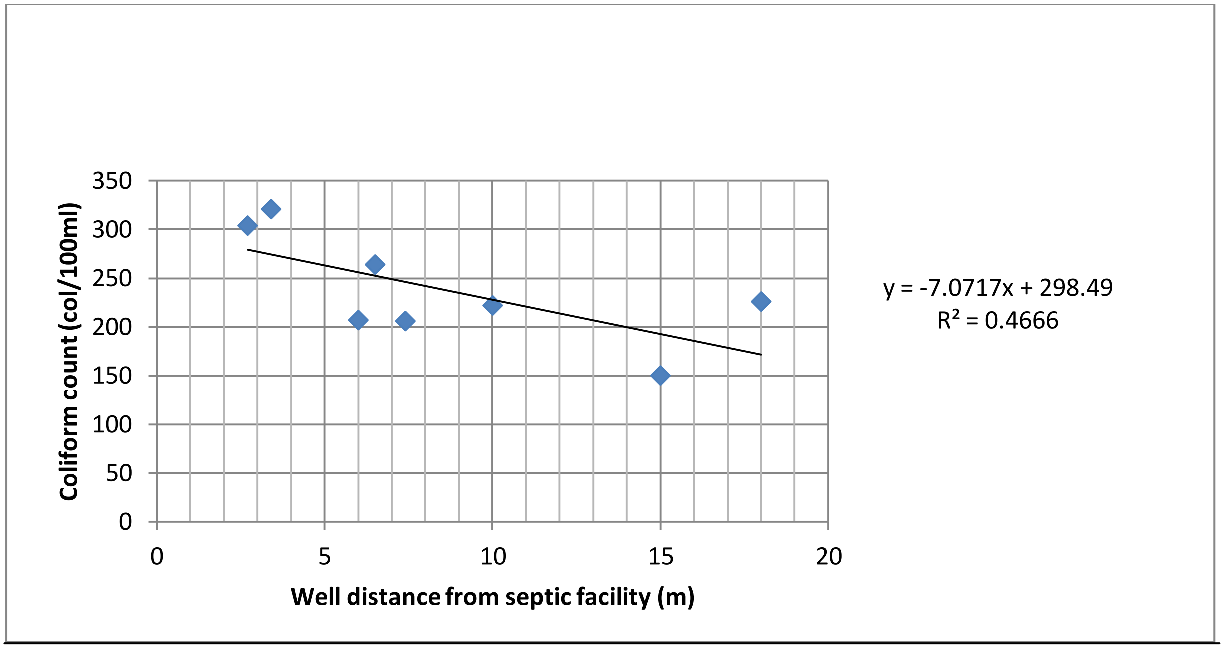

Fig. 4.19: Coliform count vs Distance
There is correlation between coliform and distance

One way analysis of variance was used to determine if there was a significant difference between the parameters and the distances of septic facility from the well and if there were also significant differences between parameters from the two areas (Adankolo and Gadumo).

The standard method of measuring correlation coefficient, r, analytically, is product moment correlation coefficient formula.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

n = number of bivariate (data pairs, x,y) values

Example.

Results obtained in test for colour concentration included, distances (x-variable) and concentration (y-variable).

Table 4.1 Layout for calculation of r for colour.

X	y	xy	x^2	y^2
6.5	9.45	61.43	42.25	89.30
2.7	17.3	43.71	7.29	299.29
6.0	8.6	51.60	36.00	73.96
18.0	8.25	148.50	324.00	68.06
7.4	9.75	72.15	54.76	95.06
3.4	18.6	63.24	11.56	345.96
10.0	8.9	89.00	100.00	79.21
15.0	9.8	147.00	225.00	96.04
$\sum x = 69$	$\sum y = 90.65$	$\sum xy=676.63$	$\sum x^2 = 800.86$	$\sum y^2=1146.88$

Where

$$r = \frac{= 8 \times 676.63 - 69 \times 90.65}{(\sqrt{8 \times 800.86 - (69)^2}) \times (\sqrt{8 \times 1146.88 - (90.65)^2})}$$

$= -0.670$ $\quad r^2 \quad = \quad 0.448$

Refer to computer value of r in table 4.2 = **-** 0.651. Coefficient of determination, r^2 is used to indicate the proportion of the total variation in the dependent variable (y) that is due to variation in the dependent variable (x).

The confidence interval is taken as 95% with level of significance, P at 5% or 0.05.

The above statistical data is contained in a soft ware, Corel Quattro Pro used in the statistical analysis for this study.

Table 4.2 Correlation of Parameters. (Correlation matrix)

	distance fr	colour	turbidity	conductivi	total dis sc	pH	Nitrate	Calcium	chloride	Tot Hard	Tot. Alkal	DO	Phosphate	Coliform c	E-coli cour
distance fr	1														
colour	-0.65143	1													
turbidity	-0.45989	0.783515	1												
conductivi	-0.89951	0.780785	0.552284	1											
total dis sc	-0.74048	0.853003	0.539827	0.924328	1										
pH	-0.75553	0.884353	0.773271	0.830384	0.770262	1									
Nitrate	-0.84318	0.895545	0.615677	0.872023	0.813327	0.841007	1								
Calcium	-0.36452	0.898566	0.660351	0.479122	0.624008	0.688359	0.759348	1							
chloride	-0.10319	0.018464	-0.40195	-0.01894	0.025015	-0.13369	0.238828	0.269073	1						
Tot Hard	0.015663	0.526494	0.374436	0.010142	0.113919	0.326403	0.451244	0.82826	0.474067	1					
Tot. Alkal	-0.24753	0.754848	0.458693	0.511912	0.721002	0.412904	0.602219	0.72502	0.027623	0.405709	1				
DO	-0.39452	0.607674	0.405892	0.663865	0.779178	0.463558	0.471454	0.331108	-0.39594	-0.16746	0.791342	1			
Phosphate	-0.75584	0.691589	0.579261	0.662165	0.54032	0.803984	0.810999	0.644076	0.33751	0.498471	0.129098	-0.02961	1		
Coliform c	-0.68312	0.796637	0.666903	0.845059	0.881011	0.691108	0.794629	0.642063	0.101298	0.239873	0.636334	0.556318	0.647365	1	
E-coli cour	-0.65197	0.883057	0.854942	0.7693	0.828754	0.846216	0.747107	0.734041	-0.10977	0.31261	0.547504	0.505631	0.713063	0.887782	1

4.3 **Discussion**

The results and analysis showing levels of physical, chemical and Biological parameters for the eight sampled wells have been presented as well as the statistical analysis.

Colour concentrations in Adankolo well 2 and Gadumo well 2 are higher than WHO stipulated level. There was generally correlation between distance and colour showing that distance affects colours, however other factors are responsible for the colour in water.

Turbidity and distance have low correlation with other factors accounting for as high as 79% of the turbidity found in water. This is true to literature as turbidity is mostly associated with surface waters.

There is a high positive electrical conductivity with distance, conductivity and TDS are related depend on the nature of the dissolved subtances. High conductivity with low TDS here has to do with the nature of dissolved underlaying rock formation.

Water is not acidic because it lies within the stipulated pH value but it was fairly alkaline (alkalinity values were a little above normal).

Nitrate is the primary in organic chemical (trace element) of concern association with septic systems. Management of ground water quality must therefore focus on nitrate. Concentrations of Nitrate was seen to correlate with distance an indication that the further away the wells are from the septic system, the better. High concentration of Nitrate in some of the water samples is an indication of infiltration of organic matter from solid wastes into the well. There were however other sources of nitrate contributing to the nitrate concentration.

Calcium and chloride were seen to have concentrations above WHO required levels which accounted for alkalinity values equally above WHO levels which made the samples hard water. It was however seen from the analysis that these concentration were due to other sources than from the septic systems as correlation of these parameters with distance were low.

Phosphate correlated with distance with the contribution from septic system more than from other sources such as dump sites, soil and trace elements.

Results of bacteriological analysis in table 3.2 showed average concentrations of coliform ranging from 150 to 304 and that of E-coli from 31 to 109. In regression, both coliform count and E-Coli correlates with distance, the closer the septic facility to the well, the more coliform count (table 4.2).

From the ANOVA, parameter qualities in Adankolo and Gadumo were compared and was discovered that both areas have similar characteristics and the qualities waters did not differ appreciably.

From the summary of results and bar charts it was noted that Adankolo well 2 (sample 2) and Gadumo well 2 had critical values. In all the physical parameters, the samples from these two wells have their concentration above WHO stipulated permissible values except in TDS and pH in which they still had highest values. In chemical parameters, these wells have concentration values above other well samples.

It was noted that these two wells were uncovered, were closest to the septic facility (2.7m and 3.4m respectively) and very low geoprobe debts of 0.4m and 0.9m respectively. It was also noted that surface run - off enters Gadumo well 2.

5. Conclusions and Recommendations

5.1 Conclusion

Results obtained show that for physical parameters, distance from septic facility did not affect colour. The factors that impart on colour came from other sources. From the correlation and regression, $P>0.05$ showing that there is no significant difference between colour and distance. Turbidity is associated with surface waters thus turbidity in the study was low. Turbidity was above the WHO limits in two wells. High conductivity with low TDS here has to do with the nature of dissolved underlying rock formation. The pH values of various samples investigated range between 8.0 to 8.4. Samples were not acidic but fairly alkaline (alkalinity value were a little above normal).

Calcium, chloride and alkalikinity values were above required permissble levels. The concentrations of calcium and chloride were responsible for the high alkalinity. However from the regression analysis the high concentration had low correlation with distance, showing that concentration were due to other sources possibly soil and refuse dump site (outside the scope of this study). Nitrate correlates with distance but has contribution from other sources.

All the wells sampled indicated the presence of coliform with count of 150 col/100ml to 321col/100ml with Adankolo wells 1 and 2, and Gadumo wells 2 and 3 having E-coli counts of between 31col/100ml to 109col/100ml. In regression analysis, both coliform count and E-coli correlates with distance. The closer the septic facility to the well, the higher the coliform count. The presence of bacteria in water samples indicate the possible presence of pathogenic (disease causing) organisms. The presence of bacteria also indicates that the sanitary conditions of shallow wells in Adankolo and Gadumo most expecially the indigenous and semi-urban areas are very poor.

Generally, it may be risky to abstract water from within 15m lateral distance of the septic facility within the study area and also possibly in an area with similar soil and water table characteristics according to the water quality parameters investigated.

5.2 Recommendation

The results revealed that inhabitants of Adankolo, Gadumo and similar areas of Lokoja who consume water drawn from shallow wells without treatment stand the risk of bacteria pollution in drinking water as the concentration of bacterial exceeded the WHO recommended limit. Hence, apart from suggesting that the well waters be treated, it is necessary to make some recommendation on the construction and siting of septic systems in such a way that it will not have any negative impacts on the well waters.

The direction of ground water flow and the distances of septic system should be considered when constructing septic systems.

Education and awareness on health risk associated with the consumption of untreated water and the indiscriminate location of wells is necessary.

Further studies should be carried out in the area of contribution of soil and depth of water in wells in order to optimize the system of abstracting ground water from shallow wells.

The results obtained from the study are true for the study areas. These results could also be applied to areas with similar soil, geology and rain fall patterns.

Clean environment round the well including covering of the well should be taken seriously.

References

Adejuwon, J.O and Mbuk, C.J (2011). Biological and physiochemical Properties of shallow wells in Ikorodu town, Lagos Nigeria. Journal of Geology and mining reseach 3 (6) 161 – 168.

Adelekan, B.A. (2010). Water quality of domestic wells in typical African Communities. Case studies from Nigeria international Journal of water resources and enveronmental Engineering 2(6) 137-147.

Cosgroved, I.N.J. and Rijsbergman, F.R. (2000). World water version, making water every business Eathsean Publiction, London U.K.

Garg, S.K. (2007). Hydrology and Water Resources Engineering, Revised Edition Khanna Publishers, Darya Ganj, New Delhi India.

Kulshreshtha, S.N (1998). A global out look for Water Resources to the year 2025. Water Resources Management 12 (3); 167-184

Meteorological Department Lokoja.

National Agency for Foods, Drugs, Administration and Control (NAFDAC) (2001). Guidelines on drinking water.

Olaniyan, I.O. Ogwuche, E.U and Olorunaiye (2009). Predicting surface water contamination form the Kaduna, Yola and Maiduguri landfill sites. Researcher 1 (6) 63-68 marslaud press N.Y.

Olaniyan, I.O., Ogwuche, E.U and Olorunaiye (2012). Ground Water contamination from septic tanks in selected part of Kaduna, Nigeria

htt/www science pub. Net/researcher. 2013.

Orebiyi, E.O, Awomeso, J.A and Oyedepo, J.A (2007). Assessment of Bacterial pollution of shallow well water in Abeokuta, South West Nigeria. Unversity of Agriculture Abeokuta Nigeria.

Rhouds, R.A and Tanner, G.A (2003). Medical Physiology 2nd Edition Baltimore; Lippincott Williams and Wilkins ISBN.

U.S EPA (1996, 1998, 2002). Water quality guidelines.

World Health Organisation (WHO) (1984,1997). Guide lines for drinking-water quality. Vol. 1 Recommendations WHO Geneva.

Zaprozec, A., (2002). Ground water contamination inventory. Amethodological guide. 1 HP-VI series on ground water No. 2 UNESCO Paris.