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Physico-Chemical and Microbiological Analysis of Well Water Samples In Settlements around Akperan Orshi College of Agriculture, Yandev

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ABSTRACT

In this study, fifteen (15) samples of well water was randomly collected from three different locations around Akperan Orshi College of Agriculture Yandev (AOCAY) and assessed for their physico – chemical parameters using standard methods and microbiological quality using serial dilution to obtain total bacteria count and the multiple tube fermentation technique to determine the coliform count using the most probable number (MPN) method. Positive tubes of the presumptive test were further cultured on appropriate solid media and the bacteria present were isolated. The chemical analysis of the samples was carried out using AAS and the results were compared with World Health organization (WHO) and Nigeria Industrial Standard (NIS) standards for drinking water. The result of the study revealed that except for nitrates and suspended solids which were higher than the WHO permissible limits, temperature was within the WHO standard but was above the NIS standards. The results of microbiological analysis of the samples indicates that most of the wells were grossly contaminated with bacteria pathogens especially, *Escherichia coli* (100%), *proteus speice* (47%) and *salmonella specie* (7%). None of the wells tested positive for *streptococcus feacalis* and *klebsiella species*. The amount of the bacteria present in the samples exceeded the standard limit of the most probable number (MPN) per 100lm set for untreated drinking without additional treatment such as boiling or disinfection and this could lead to outbreak of water borne diseases. Hence, good and proper environmental and personal hygiene must be maintained specially by the use of these wells to prevent their contamination with bacteria pathogens.

Key words: *Well Water, Physico- Chemical, Microbiological, Contamination, Pathogens*

1. INTRODUCTION

Safe drinking water is a basic need of humanity. Lack of it leads to mobility and mortality, especially in local communities where chemical pollutants and water borne diseases are prevalent and persistent due to low quality groundwater and surface waters (Basavaraja et al, 2011). Most people in developing countries depend upon polluted groundwater sources due to lack or inadequate quality water sources (Stephen T. Odonkor and Kennedy K. Addo, 2013). Water is useful to man in many ways, in the first place for his physiological existence. It is used domestically for washing, cooking, bathing e.t.c. It also serves as a source of transportation, for irrigation, propagation of fish and other aquatic systems and generation of fish and hydro-powers. Water is the source of energy and governs the evolution and functions of the universe on earth (Kataria, H.C. et al, 2011). However, since the beginning or recorded history, water has been recognized as a potential carrier of germs and diseases (Retra 2002). According to Nsi, E W and Ogori B. O. (2005), groundwater sources such as wells, boreholes and springs; that are properly located produce water of a very good quality but most often than not contain pathogens that endanger human health. Suitability of water for various uses depends on the type and concentration of dissolved minerals and groundwater has more mineral composition than surface water (Mirribasi et al, 2008). The quality of groundwater is constantly changing in response to daily, seasonal and climatic factors. Continuous monitoring of water quality parameters is highly crucial because changes in the quality of water have far reaching consequence needs in terms of its effects on man and biota. Contamination of groundwater also depends on geology of the area and it is rapid in hard rock areas especially in the area of limestone regions, where cover systems are below the water table. The changes in quality of groundwater response to variation in physical, chemical and biological environments through which it passes (Singh *et al.*, 2006).

The global environment is changing continuously due to unfavourable alteration of surroundings, wholly as a by product of the actions of man through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution of organisms. These changes may affect man directly or through his supplies of water and agricultural and other biological products (Kataria, H.C. et al, 2011). Chemicals are the major source of water contamination that is introduced during water movement through geological materials, manufactured chemicals may cause problems. Fertilizers, insectides and pesticides are major contributors to water pollution. Nitrates from fertilizers are a common chemical pollutant of water. Heavy metals, sulphates, nitrates, chlorides, phosphates, carbonates, ammonia, pesticides, phenols, soaps, detergents are the common chemical pollutants. There are a number of pathogenic micro organisms which cause water borne diseases in man. Among the metals, the severe

pollutants are lead, cadmium, arsenic, copper, zinc, manganese, iron and calcium (Kataria, H.C. et al, 2011).

Majority of the infections that has ravage humanity are those that are associated with the lack of accessibility to portable water supply and poor environmental sanitation. This affects man and animal existence especially in developing countries. The following are micro-organisms associated with water; *pseudomonas aeroginosa, salmonella, mycobacteria, klebsiella, lyanobacteria, Escherichia coli, proteus, shigellasonnei* e.t.c. (Chris, 2004). Water borne diseases are caused by pathogenic micro-organisms which are directly transmitted when contaminated water is consumed. Cholera is a good example of water borne disease and it is endemic in some parts of Nigeria. In 1991, more than 16,000 people died worldwide from half a million cases of cholera (Ashbolt, et al, 2001). Improved treatment has reduced the death rate drastically, but it is still a serious disease. Diarrhea is the World's second leading killer of children under the age of five after pneumonia, claiming about 1.5 million children a year more than Aids and measles combined. (Muhammad Abdullahi, et al, 2013). Disease causing micro organism transmitted via drinking water are predominantly of faecal origin and are referred to as enteric pathogens (Ashbolt, 2001). The World Health Organization (WHO) estimates that about 1.0 million people globally drink unsafe water and the vast majority of diarrhea disease in world (88% is attributable to unsafe water, sanitation and hygiene (Obire 2005). Poor water quality, sanitation and hygiene account for 1.7 million deaths a year worldwide (3.1% of annual deaths) and 3.7% of the annual health burden (Ashbolt 2004) disability adjusted life year (DALYS) worldwide (54.2 million) mainly through infections diarrhea and nine out of ten such are in children and virtually all of the death, are in developing countries.

As per World Health Organization (WHO) standards, drinking water should not contain any micro organisms known to be pathogenic or any bacteria indicative of faecal pollution (WHO 1993).

Pollution of groundwater has gradually been on the increase especially in our cities with lots of industrial activities, population growth, poor sanitation, land use for commercial agriculture and other factors responsible for environmental degradation (Egila and Terhemen, 2004). The concentration of contaminants in the groundwater also depends on the level and type of elements naturally or by human activities distributed through the geological stratification of the area. The present of such contaminants in the groundwater above the recommended standard set by water quality regulating bodies like NIS, EPA, FEPA and WHO may result in serious health hazards (USEPA, 2002). This perceived consequence of consumption of unregulated waters (used as portable water) has triggered various studies on water quality and aquatic ecosystem. (Ekpete, 2002; Olabisi et al, 2008; Aiyesanmi et al, 2004; Egila and Terhemen, 2004; Idowu et al, 2011; Bolaji and Tse, 2009 e.t.c).

The main sources of water supply for domestic and agricultural use in the study area are the untreated wells and some private and commercial boreholes. This is because the expected treated public water scheme is not available and the cost of obtaining water from commercial water processing packaging companies for consumption is quite high and cannot be afforded by many. To avoid any health hazard inherent in the possible consumption of disease infected/ contaminated water, physical-chemical and bacteriological study of water in the area is unavoidably important. It is against this backdrop that this study is carried out to determine whether these parameters meet the Nigeria Industrial Standard (NIS) and World Health Organization (WHO) standard for drinking water as well as to ascertain the possible causes of any contaminations in other to make appropriate recommendations.

2. MATERIALS AND METHODS

2.1. Study area and sampling

This study was restricted to settlements around Akperan Orshi College of Agriculture Yandev, Gboko, (7.325°N: 9.005°E) of Benue State, Nigeria with a population of about 200,000. The area has a clustered settlement pattern and is presently inhabited predominantly by local communities, students and staff of the college. Five samples were randomly collected from each settlement as follows:-

Settlement A comprised of samples from Dzomon Quarters, Settlement B comprised of samples collected from Tarukpe area while Settlement C comprised of samples collected from settlements along Makurdi Road. All the samples were collected in sterile bottles and were taken immediately to Benue State water board Makurdi for analysis.

2.2. Physico-chemical analyses of the water samples

All procedures carried-out to examine the water samples were performed according to Standard Methods for the examination of water and wastewater (APHA, 1998, 1996), and examination of water for pollution control (WHO) and guidelines for drinking water (WHO, 2004, 1996). Chemical analyses of the water samples were done using the Atomic Absorption Spectrophotometer (AAS) method.

3. MICROBIOLOGICAL ANALYSIS OF THE SAMPLES

3.1. Isolation of bacteria using plate colony count method:

15g of (CLED) Cystine-lactose-Electrolyte-Deficient medium was dissolved in 1 litre of distilled water and autoclaved at 121^0c for 15minutes and left to cool (APHA 1998). The top of the conical flask was wrapped with foil to prevent contamination. The area (bench) where the work was done was cleaned with detol and water.

3.2. Culturing, incubating, Colony count and identification

The pour plate method was used for culture. The Petri-dish was shaken in an anticlock wise direction to enable the agar that was poured into it set and spread evenly. The plates of bacteria count were kept in the incubator at 37^0c for 24hours. Colonies appeared as clusters and each plate was counted and recorded.

10ml of Maconkey broth was filled in 15 bottles using sterile syringe. The inverted Durham tubes were inserted in each of the bottles and then autoclaved for 15minutes at 121^0c. The bottles were then removed and placed in a sterile environment. 10ml of the water was inoculated in the first five bottles. 1ml of the water was inoculated in the second five bottles, while O.1ml of water was inoculated into the last five bottles. The bottles were kept into an incubator and observed at the end of 24 and 48hours for presumptive and confirmatory test respectively. The number of positive bottles indicated by colour change and gas formation in each of the roll was recorded and compared-with bacteria load in the MaCcrady table (APHA 1998). This procedure was repeated for all the water samples.

4. RESULTS AND DISCUSSION

The results of physico-chemical parameters obtained from samples of well waters analysed are shown in Table 1.

Table 1: Physico-chemical parameters of the samples

Sample	Temp (℃)	Colour (pt/co)	Turb (FTU)	Cond (µs/cm)	PH	TH (Mg/L)	ALK (Mg/L)	SO_4^{2} (mg/L)	NO_3^{2-} (Mg/L)	Cl^- (Mg/L)	Mg (Mg/L)	Ca (Mg/L)	Fe (Mg/L)	Cu (Mg/L)	Pb (Mg/L)	DO_2 (Mg/L)	BOD (Mg/L)	SS (Mg/L)	TDS (Mg/L)
A_1	33.00	2.00	0.00	67.40	6.00	60.00	7.14	18.00	28.60	21.90	20.00	40.00	0.17	0.54	<0.001	2.00	1.20	30.00	60.00
A_2	30.00	3.00	1.00	62.30	6.20	80.00	7.10	20.00	38.40	27.10	30.00	20.00	0.23	0.86	<0.001	2.50	1.22	32.00	62.00
A_3	35.00	2.00	2.00	61.50	6.60	60.00	7.20	25.00	38.40	22.50	25.00	30.00	0.08	0.30	<0.001	2.60	1.30	35.00	70.00
A_4	33.00	1.00	3.00	60,20	6.30	68.00	7.50	16.00	33.50	25.60	30.00	40.00	0.15	0.42	<0.001	3.00	1.10	33.00	66.00
A_5	34.00	4.00	0.00	63.10	6.20	70.00	8.20	27.00	28.00	30.20	32.00	60.00	0.22	0.66	<0.001	2.82	1.00	30.00	65.00
B_1	34.00	4.00	1.00	80.60	6.68	40.00	7.68	20.00	38.40	20.70	40.00	60.00	0.21	0.72	<0.001	4.00	2.50	35.00	65.00
B_2	31.00	3.00	0.00	82.30	6.00	30.00	7.26	30.00	32.10	25.10	30.00	40.00	0.18	0.35	<0.001	3.15	2.22	30.00	60.00
B_3	34.00	2.00	3.00	81.40	6.30	50.00	7.30	15.00	30.20	28.30	20.00	20.00	0.09	0.46	<0.001	3.20	2.20	34.00	66.00
B_4	33.00	1.00	2.00	84.30	6.50	60.00	7.20	40.00	34.00	29.50	20.00	18.00	0.16	0.81	<0.001	2.20	2.40	32.00	68.00
B_5	32.00	2.00	1.00	85.00	6.20	35.00	7.10	25.00	35.00	31.20	30.00	26.00	0.20	0.28	<0.001	2.00	2.50	33.00	67.00
C_1	33.00	1.00	0.00	71.20	6.30	80.00	7.30	22.00	36.40	23.70	30.00	60.00	0.18	0.76	<0.001	3.05	3.12	34.00	68.00
C_2	34.00	4.00	0.00	72.80	6.50	100.00	7.50	20.00	37.20	25.30	20.00	60.00	0.20	0.62	<0.001	3.10	3.10	33.00	66.00
C_3	34.00	3.00	2.00	73.40	6.00	70.00	7.60	28.00	38.40	24.20	40.00	35.00	0.19	0.37	<0.001	2.40	3.50	32.00	64.00
C_4	34.00	3.00	3.00	71.50	6.20	60.00	7.80	32.00	35.50	22.70	25.00	50.00	0.20	0.42	<0.001	2.30	2.00	30.00	62.00
C_5	32.00	2.00	1.00	75.20	6.50	50.00	7.20	30.00	30.00	28.60	28.00	50.00	0.14	0.52	<0.001	2.12	2.15	30.00	60.00
WHO Std	25-36	1-5	5	300	6.5-8.5	150	200	250-500	10	250	150	75-200	0.30	1.0-2.0	0.001	NA	NA	5	1000
NIS Std	25-32	-	5	1000	6.5-7.5	150	-	-	-	200	-	-	0.30	-	0.001	-	-	-	-

Temperature of all the samples analysed ranged from 30.00-35.00℃. The temperature of water samples from the first (A) settlement (Dzomon Quaters) ranged from 30.00-35.00℃, that of settlement B (Tarukpe) ranged from 31-34℃ while that of settlement C (Makurdi Road) ranged from 32.00-34.00℃. These values obtained are similar to those reported by Braid, C and Cann, M. (2004) and Aderibigbe, et. al (2008) and they are above NIS standards but are within the WHO standards. The colour of the well water samples ranged from 1.00-4.00pt/co. Samples from all the settlements gave the same range of colour from 1.00-4.00pt/co which is also within the limits of NIS and WHO. Turbidity (Turb) of water refers to the clarity of the water. The greater the amount of suspended solids in the water, the murkier it appears, and the higher the measured turbidity. High turbidity levels are often associated with high levels of disease causing organisms. The turbidity of the well water samples from all the settlements ranged from 0.00-3.00 FTU. All the settlements had the same range for turbidity of 0.00-3.00FTU which also conforms to the NIS and WHO standards. The conductivity of all the sampled well waters ranged from 61.50-85.00 µs/cm. The conductivity (Cond) of well water from settlements A ranged from 61.50-67.40µs/cm that of settlement B was 80.60- 85.00µs/cm while the electrical conductivity of samples from settlement C ranged from 71.20-75.20µs/cm. In all the samples analysed, the second settlement had the highest electrical conductivities while the third settlement had the least conductivity values. However, all the electrical conductivity values were within the WHO and NIS standards.

The pH values obtained from all the samples ranged from 6.00-6.68.Settlement A had pH values ranging from 6.00-6.60, the pH value for settlement B ranged from 6.00-6.68 while that of settlement C ranged from 6.00-6.50. All the pH values of the samples fell within the WHO and NIS permissible limits of 6.50-8.50 and 6.50-7.50 respectively. These pH values indicate that the groundwater of the sample areas is slightly acidic. According to Adefemi, S.O and E.E. Awokunmi (2010), acidic water results in corrosion of iron and steel materials such as pipes, clogging of distribution pipes cause objectionable taste of drinks and food and stain clothes and rust cooking utensils. Total hardness of all the sampled well waters ranged from 30.00-100.00mg/L. The range of total hardness (TH) for settlement A was 60.00-80.00mg/L, which for settlement B was 30.00-60.00mg/L while the total hardness for settlement C ranged from 50.00-100.00mg/L. These values fell below the WHO and NIS of 150.00mg/L. The WHO international standard for drinking water (1998) classified water with a total hardness of $CaCO_3$ <50mg/L as soft, 50-150mg/L as hard. Based on this classification, all the water samples analyzed are moderately hard, thus, the water are suitable for domestic use in terms of hardness. This is because; moderately hard water is preferred to soft water for drinking purposes as hard water is associated with low death rate from heart diseases (Adefemi, S.O and E.E. Awokunmi, 2010). The alkalinity (ALK) values of all the sampled water ranged from 7.10-8.20mg/L. Alkalinity values from settlement A ranged from 7.10-8.20mg/L, settlement B alkalinity values ranged from 7.10-7.68mg/L while alkalinity values from settlement C ranged from 7.20-7.80mg/L. All these values of alkalinity from the sample areas fell below the WHO standard limit of 200mg/L while there is no limit of alkalinity by NIS. All the samples analyzed for sulphates (SO_4^{2-}) gave values ranging from 18.00-40.00mg/L. Sulphate values from settlement A ranged from 18.00-27.00mg/L, settlement B sulphate values were 15.00-40.00mg/L while the range of values for sulphate from settlement C were 20.00-32.00mg/L. All these values of sulphate from the samples were quite below the WHO permissible limit of 250-500mg/L. The nitrates (NO_3^-) content of the samples from the study area ranged from 28.00-38.40mg/L. A breakdown of the amount of nitrates in all the settlements were; settlement A; 28.00-38.40mg/L, settlement B; 30.20-38.40mg/L while that of settlement C was 30.00-38.40mg/L. The WHO maximum recommended value for nitrates in water is 45mg/L, however maximum acceptable concentration in drinking water should not be more than 10 mg/L. This result means that the values are above the WHO permissible limit of 10mg/L for drinking water. The high levels of nitrates in the samples could be attributed to heavy use of fertilizers in the study area which have the ability to seep into ground waters. According to Stephen T. Odonkor and Kennedy K. Addo (2013), high levels nitrate (NO_3^-**)** are often an indicator of contamination by human or livestock wastes, excessive fertilization, or seepage from dumpsites. Earlier works have contended that nitrates above 44mg/L in drinking water could cause methemoglobinea (blue water body) in children and death in farm animals (Olabisi, et al 2008). The amount of chloride ion (Cl^-) present in all the samples of well water analyzed ranged from 20.70-31.20mg/L. The amount of chloride ion in samples obtained in settlement A ranged from 21.90-30.20mg/L, that of settlement B was 20.70-31.20mg/L while that of settlement B ranged from 22.70-28.60mg/L. These values of chloride ion in the samples are quite below the recommended standard values of 250mg/L and 200mg/L by WHO and NIS respectively. According to Ekpete (2002); excess of chloride ion in water may cause edema.

The total amount of Calcium in all the samples ranged from 18–60 Mg/L. Samples from settlement A ranged from 20–60Mg/L while the range of values from settlement B was between 18–60Mg/L, the values from settlement C ranged from 32-60Mg/L. These values of Calcium obtained from the study area were below the WHO standards. The values of magnesium obtained from the samples of water ranged from 20-40Mg/L. The breakdown of the magnesium values from individual settlements were; 20-32Mg/L for settlement A, 20-40Mg/L for settlement B while that of settlement C ranged from 20-

40Mg/L. The values for both calcium and magnesium are high but are within the WHO permissible levels. These high values of the metals in the water may be responsible for the moderate hardness of the samples. The amount of iron in the samples ranged from 0.08-0.23mg/L. Settlement A showed a range of iron values from 0.08-0.23mg/L, a range of 0.09-0.21mg/L was observed in settlement B while settlement C gave values for iron ranging from 0.14-0.20Mg/L .Overall Settlement C gave the highest values for iron. However, all the values of iron were within the WHO and NIS Standards of 0.30Mg/L. The values of copper in all the samples of water under consideration ranged from 0.28-0.86Mg/L. A breakdown of the values of copper in each sample area were; settlement A gave a range of values from 0.30-0.86Mg/L, Settlement B gave a range of 0.28-0.81mg/L while a range of 0.37-0.76Mg/L was obtained from settlement C. All the values of copper were below the WHO range of 1.0-2.0mg/L. The amounts of lead in all the samples considered in this sturdy gave the values of lead less than 0.001 which is the WHO and NIS permissible limits for lead in drinking water.

Currently there are no WHO and NIS standards for Dissolved Oxygen (DO) and Biological Oxygen Demand (BODs). However it is observed from the table1 that dissolved Oxygen (DO) did not vary much. The range of values of Dissolved Oxygen (DO) obtained in all the samples was from 2.00-4.00Mg/L. Settlement A gave the range of DO from 2.00-3.00mg/L, a range of 2.00-4.00Mg/L was obtained from settlement B and a range of 2.12-3.10Mg/L was obtained from settlement C. Biological Oxygen Demand (BOD) from all the samples ranged from 1.10-3.50mg/L. The amount of BOD from the first settlement (A) ranged from 1.10-1.30Mg/L, the amount of BOD from settlement B was from 2.20-2.50Mg/L while the amount of BOD obtained from settlement C ranged from 2.00-3.50mg/L. Samples from settlement C indicated the highest range off values for BOD.

The results for the amount of Suspended Solids (SS) in all the samples obtained ranged from 30-35Mg/L. A breakdown of the amounts of SS in the various settlements indicated that settlement A gave a range of 30.00-35.00Mg/L, Settlement B showed a range of 30.00-35.00Mg/L while the range of Ss for settlement C was from 30.00-34.00Mg/L. All values of SS from the samples were above the permissible limits set by WHO. Total Dissolve Solids (TDS) in all the samples ranged from 60-70Mg/L. The highest TDS values were obtained from settlement A with a range of 60-70Mg/L, the was followed by settlement C with TDS ranging from 62-68Mg/L while settlement B gave the least values of TDS range of 62-68Mg/L. All these values of TDS were below the WHO standards. All the samples considered in this study had unobjectionable taste and odour.

The total viable bacteria counts obtained are shown in table 2.

Table 2: Total viable count of bacteria of the samples

Bacteria	Samples														
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
E. coli ($\times 10^3$) (Cfu)	12	38	24	6	18	17	44	23	56	74	84	22	33	76	41
Proteus specie $\times 10^3$ (cfu)	-	14	-	-	-	13	-	-	-	36	42	14	-	28	5
Streptococcus Feacalis ($\times 10^3$) cfu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Salmonella Specie ($\times 10^3$) cfu	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Klebsiella Specie ($\times 10^3$) cfu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

All the samples analyzed show positive test for *E. coli*. This indicates 100% pollution of the well water samples in the study area with the bacteria ranging from 6 x 10^3 - 84 x 10^3 Cfu. The total viable *E.* coli present in the five samples from settlement A ranged from 6 x 10^3 – 38 x 10^3 Cfu. While those obtained from settlement B ranged from 17 x 10^3 - 74 x 10^3 Cfu. The samples from settlement C showed a range of 22 x 10^3 – 84 x 10^3 Cfu.

Sample from study area A showed the least *E.* coli pollution followed by those from area B and those from area C show the highest level of pollution with *E.* coli.

The total viable count for *proteus species* in the samples ranged from 5 x 10^3 – 42 x 10^3 Cfu. The amounts indicate 47% pollution of the samples with the bacteria. Samples obtained from study area A only show positive test out of the five samples analyzed with *proteus species* while two positive tests was obtained from samples from study area B. Four out of the five samples obtained from the study area C show positive test for *proteus specie* indicating a high rate of pollution of wells from the area with the bacteria.

Similarly, only one sample obtained from the three study areas showed positive test for *Salmonella specie*.

The bacteria were only obtained from the first sample from area A while the other samples showed a negative result indicating low pollution of the samples with *salmonella specie* (7%). The result of the analysis did not show presence of *Streptococus feacalis* and *Klebsiella specie* in the samples obtained from the three locations of the study areas.

The presumptive coliform count measured by the most probable number (MPN) per 100ml, using five tubes of 10ml, five tubes of 1ml, and five tubes of 0.1ml in the fermentation tube from the well water samples from the different locations are indicated in table 3.

Table 3: presumptive coliform count of the samples

Samples	10ml tube Positive	1ml tube Positive	0.1ml tube Positive	Most probable no. (MPN) per 100ml
A_1	3	2	1	17
A_2	5	4	1	275
A_3	5	5	3	170
A_4	3	1	0	11
A_5	4	3	0	40
B_1	4	2	2	25
B_2	5	4	2	350
B_3	4	3	2	175
B_4	5	4	3	425
B_5	5	4	3	425
C_1	5	4	3	425
C_2	5	3	2	200
C_3	5	4	1	275
C_4	5	4	3	425

C_5	5	4	2	350

The most probable number (MPN) per 100ml for the well water sample ranged between 11 and 425 which clearly exceeded the standard limit set by the World Health Organization (W.H.O2. 1996).

The high bacteria pollution observed in the study may be3. attributed to both the shallow depth at which water is tapped, settlement pattern and land use practices. The location of wells also does not take water quality into cognizance. Wells are often located too close to sanitation systems and almost all the4. well used bailer as mode of collection.

The bacteria pollution of shallow wells around AOCAY is5. anthropogenic in origin. The high human concentration in these locations enhances the use of pit latrines and septic soak away which are often located too close to the wells in most6. households. In addition to this, free ranging domestic animals and other domestic solid wastes which are dumped around the houses are possible sources of bacteria pollution of the shallow wells.

Besides, there is tendency for higher rate of infiltration of precipitated water during the rainy season. High level of feacal bacteria in water samples indicates the possible presence of pathogenic (disease causing) organisms. From the result of the bacteria identification carried out, it is evident that disease such as cholera, typhoid fever, bacteria dysentery, infectious hepatitis and food poisoning can possibly result from the consumption of the untreated water. Eye, ear, nose and throat infections can also spread from contact with the water. The presence of these bacteria indicates that the sanitary conditions of shallow wells around AOCAY most especially the Makurdi road and Tarukpe areas are very poor.

5. CONCLUSION

This study has shown that most of the physico – chemical parameters considered were below the WHO and NIS standards for drinking water with the exception of temperature, nitrates and suspended solids. There is a high incidence of contamination of well water by the pathogenic organisms. To reduce the outspread incidence of contamination of the well water, it is advocated that well dug must be deep and covered adequately. Also good and proper personal and environmental sanitary practices must be maintained in and around the wells.

RECOMMENDATION

From the fore- going findings, it is recommendation that:-

1. Physico – chemical and microbiological examination of drinking water samples from the sturdy area and disinfection should be done periodically to prevent the spread of pathogenic microbes.

2. Good sanitary condition of wells should be maintained at all times to minimize the contamination of the well water.

3. Boiling and other disinfection methods of well water obtained in the study area should be done before usage of the water.

4. Pit latrines and septic tanks should be located very far away from the wells.

5. Free ranging domestic animals and other animals should be avoided to prevent contamination of well water.

6. Deep wells should be constructed and adequately covered to prevent contamination

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