International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Quality Assessment of Some Selected Borehole Water Samples in Dutsinma Town Katsina State Nigeria

[1]Engr. Mansur Abba, [2]Engr. Suleiman Abba

[1]Chemical Engineer, Jibia Water Treatment Plant, Katsina State Water Board, Nigeria
[2]Environmental Officer, National Oil Spill Detection and Response Agency, Abuja Area Office

ABSTRACT

The research was carried out to investigate and analyse the quality of some selected borehole water samples in Dutsinma Town, Katsina State Nigeria. Physical (pH, Turbidity, TDS and colour), chemical (Total hardness, Calcium hardness, Magnesium hardness, Chloride and salinity), bacteriological (MPN method was used) and heavy metals (Lead, Manganese, Cadmium, Arsenic, Chromium) concentrations were all analysed. The values recorded showed that, the bore hole water samples were of standard quality, because the values were within the limits of WHO.

Key Words: pH, Turbidity, Cadmium, MPN method

Introduction

Water is one of the basic needs for living organisms (both plants and animals) to live on Earth.For human beings, it is not water per say; but clean and pure one.A clean and pure water is the one which do not have anydisease-causing pathogens and which undergoes proper water treatment processes, and thus ready for consumption(WHO, 2017). It is vital for societies to have clean and pure water, as shortage of it, causes water borne diseases, which are killer diseases (WHO , 2017). That is why, World Health Organization (WHO), put much emphasis on clean water and is always ensuring that people in both rural and urban have access to clean water; not only WHO, but government and private organizations. Despite the fact that 70% of the earth is covered with water , only 3 % of the water is clean , pure and safe for drinking (WHO , 2011).These statistics, is what makes providing clean water to societies by policies makers a daunting challenge, because currently about 1.1 billion people (both rural and urban) are facing and experiencing the problem of clean water shortage (WHO , 2011).This roughly affects 27% of world population and thus highlighting the real threat the problem is causing . Treatment of drinking water involves a number of combined processes based on the quality of the water source such as turbidity, amount of microbial load present in water and the others include cost and availability of chemicals in achieving desired level of treatment (Muyibi *et al.*, 2009). Conventional methods used for treatment and purification of water include coagulation, sedimentation, filtration aeration and disinfection. These methods are widely adopted in wastewater treatment. Coagulation promotes aggregation and formation of flocs, where the ions of the coagulant, will attract the dissolved suspended particles in the water. Sedimentation helps to settles the flocs formed during coagulation, and disinfection kills disease causing pathogens which maybe present in the water. It is the components that promote aggregation and sedimentation of suspended particles in a solution (Nharingo *et al*., 2015).

The two sources of water are divided into surface water and underground. Land use is becoming less and less due to lower water levels, lower groundwater and higher salinity. This all leads to deterioration of groundwater. Easy access with low capital investment and reliability (Degraff *et al.*, 2017).As a result of all these, there is an increasing need to focus on the use of surface water for drinking. However, due to the presence of silt, clay and natural organic matter, the surface water is very turbid (Ayekoe *et al.,* 2017).The general application of coagulation and agglomeration, resulted in the addition of aluminum, iron and polyelectrolyte salts (Oladoja *et al*., 2017).Coagulation can be widely defined as a process comprising chemical addition, rapid mixing and flocculation. Coagulation is often the first process of unity in water treatment and is very important for eliminating suspended and dissolved particles. The coagulation and flocculation processes are designed to produce quite significant particles to separate and eliminate in future sedimentation or explanatory alternative processes.

PROBLEM STATEMENT

It is imperative for societies to have clean and pure water.This is because , its shortage causes water borne diseases , which are indeed killer diseases. Although , the earth is covered with 70 % water , only 3% of the water is clean , pure and safe for domestic purpose (especially drinking).Water which is not safe for consumption and other domestic purposes is the one which do not meet WHO standard , interms of physical , chemical and bacteriological parameters.

JUSTIFICATION

Subjecting the water samples to physicochemical , bacteriological and heavy metal analysis , will ensure the quality of the selected bore hole water samples.This will also help to provide safe , portable , clean and pure water.This will also help to reduce the menace of water borne diseases , and thus healthy societies

AIM OF THE STUDY

Having safe drinking water is a human needs and rights for every man, woman and child. People need clean water to maintain their health and dignity. Having better water is essential in breaking the cycle of poverty since it improves people`s health, strength to work, and ability to go to school, the main aim of this research is to give an account on the quality of the borehole water, whether the water is safe (of good quality) for human consumption or no ;In other way this research also aim to serve for a monitoring purpose to check whether the water quality is in compliance with the standards (WHO and SON standards for drinking water), and to monitor the efficiency of a system, working for water quality maintenance.

BROAD OBJECTIVES

A broad objective of this research work is to analyse and ensure the quality of borehole water samples collected at different locations in Dutsinma Town (that is newly constructed bore hole)

SPECIFIC OBJECTIVES

The specific objectives of this work are:

- To analyse the physical parameters of the borehole water samples.
- To analyse the chemical parameters of the borehole water samples
- To analyse the heavy metals in the borehole water samples
- To conduct bacteriological analysis of the bore hole water samples

LITERATURE REVIEW

In Kabo Area of Kano State, Iliyasu (2009) research shows, the ground water of that area has an average TDS of 237mg/L, pH of 7.1, conductivity of 521.37micro-ohm/mL, chloride of 47.71mg/L, nitrate of 3.8mg/L, fluoride of 0.18mg/L, bromide of 0.60mg/L, sulphate of 14.0mg/L, and hardness of 157.80mg/L. Hence water was categorized as good for both domestic, agriculture, fish farming, livestock and industrial use in the study area compared with WHO and EPA standards of 1996 and 2003 respectively.

Ibrahim and Nuraddeen (2014) reported that in Dutsin-ma metropolis, Katsina State, the average means value of pH for the borehole and hand-dug well are 6.91 and 6.6, for turbidity 5 and 7.5NTU, for conductivity 575.4µS/mL and 537.5µS/mL respectively. Suggested that the quality of the water from two main sources in Dutsin-ma town are comparable to the internationally accepted level of FAO (1954), WHO (1993) and EU (1998).

In the basement complex areas of Kano State, Adamu et al.,(2013) research shows that, total of twenty (20) boreholes were selected at random across the state. Thirteen (13) relevant parameters on the test of water quality were taken into consideration. The research found out that underground water in the area is safe for drinking due natural filtration process that the water undergo, because, the soil chemistry and mineralogy alters the chemistry of the water there by making it safe for drinking by meeting the standard requirement of World Health Organisation (WHO 1984).

Maureen *et al.,* (2012) in Okutukutu Bayelsa State, research shows that: Treated water samples were collected from all twenty one (21) functional boreholes in Okutukutu using standard techniques. pH, Turbidity, Iron, Nitrate, Chlorine, Calcium, Magnesium and E. coli, in the water samples were determined using standard procedures. All physico-chemical parameters in borehole water samples were within recommended standards. Residual chlorine at the sample tap was less than recommended amount of 0.2mg/l in 61.9% of the boreholes. All borehole samples tested negative for E. coli. 66.7% of stored borehole samples in household tested positive for E. coli but was negative for all other enterococci bacteria.

Momodu and Anyakora (2010) in Surulere of Lagos research results of heavy metal contamination of ground water shows that, none of the samples analysed contained Aluminium in concentrations above the MCL, however, the metal was found to be pre sent in 93.88% of the samples analysed. Over 38% of the samples had Cadmium present in them and 32.65%of the samples had Cadmium concentrations. Almost 60% of the samples had detectable level of Lead while 36.73% of the sample had Lead concentration. In general 97.96%of all samples analysed contained one or more of the three heavy metals studied each in varying concentrations. The results obtained from this study suggest a significant risk to this population given the toxicity of these metals and the fact that for many, hand dug wells and boreholes are the only sources of their water supply in this environment.

Abubakar and Adekola (2012) studied on the Assessment of borehole water quality in Yola-Jimeta Metropolis, The study reveals that chloride (Cl-), iron (Fe2+), nitrate (NO2-), pH, sodium (Na+) and total hardness (CaCO3) are the main sources of borehole water contamination in the study area. This has health implications that include hypertensions, heart and kidney diseases which are on the increase in the region. Poor sanitary condition and intensive use of inorganic fertilizer are implicated as sources of contaminants. We therefore suggest the setting up of water sanitary agencies that will monitor and regulate health based targets of water quality at ward levels.

Anake *et al*., (2013) investigate the physic-chemical and microbial assessment of different water sources in Ota, Ogun State and Results of the values of the surface and potable water in the study area showed that turbidity(0.19 to 11.6 NTU), conductivity (36.5 to 396 µS/mL), salinity (10 to 80mg/L), alkalinity (0 to 64 mg/L), nitrate (0.20 to 4.60 mg/L), total hardness (5.0 to 80.0 mg/L), total solid (4000 to 7000 mg/L) total suspended solids (3967 to 6978 mg/L) total dissolved solids (17.9 to 198 mg/L), dissolved oxygen (4.50 to 9.60 mg/L), biochemical oxygen demand (ND to 4.67 mg/L). The physicochemical parameters of most of the samples analysed were within the limits set by both National and International standard regulatory bodies for drinking and domestic waters (SON, 2007; WHO, 2011). Overall, the potable water sources are suitable for drinking, but the faecal contamination in Iju Rivers make it unfit for drinking.

Anyanwu and Okoli (2012) research on Evaluation of the bacteriological and physicochemical quality of water supplies in Nsukka and The mean total bacteria count of the water samples ranged as follows: bore hole (0.92 ×104 to 1.41 ×104) cfu/mL, well water (1.80 ×104 to 2.40 ×104) cfu/mL and spring water (0.78 ×104 to 1.06 ×104) cfu/mL. The mean total coliform count of the samples in (MPN/100 mL) ranged as follows: borehole (10 to 15), well water (14 to 18) and spring water (8 to 10). The isolated and identified bacteria were Enterobacter spp., Alcaligenes spp., Escherichia coli, Proteus spp., Klebsiella spp., Pseudomonas aeruginosa, Acinetobacter spp., Staphylococcus aureus and Bacillus sp. The physicochemical values of the water samples ranged as follows: pH (5.6 to 6.4), dissolved oxygen (DO) (5.4 to 6.4), biochemical oxygen demand (BOD) (10.0 to 20.4), chloride (1.6 to 2.3) mg/L, total hardness (48.6 to 68.0) mg/L, total dissolved solids (6.3 to 9.7) mg/L, sulphate (2.0 to 3.4) mg/L and nitrate (1.2 to 4.1) mg/L. The water supply sources in the present study have good physicochemical attributes for human consumption but the presence of E. coli and other potential enteric pathogens indicated faecal matter contamination of the water implying that they are not suitable for human consumption.

Tubonimi *et al.,* (2010) research of the assessment of water quality along Amadi creek in port-harcourt shows that, the results of the analyses of the water samples showed low nutrient levels with ranges of dissolved oxygen (4.87-15.42 mg/L), pH (6.73-7.33), alkalinity (76-90 mg/L), electrical conductivity (20000-36100 µS/mL), total dissolved solids (14000-25270 mg/L), chloride (3211-9682 mg/L), Sulphate (382.44-2107.32 mg/L), phosphate (0.05 mg/L), nitrate (0.11-0.26 mg/L), total hardness (2880-2352 mg/L), Biochemical oxygen demand (3.25-12.99 mg/L), Ca2+ (192-384.0 mg/L), Mg2+ (433.34-1358.59 mg/L) and BOD-NO3- ratio of 28.2. Dry season levels of the parameters were generally higher than wet season levels. The difference between them was statistically significant ($P<0.05$). The levels of EC, BOD, TDS, TH, Ca2+, Mg2+, SO42- and Cl- exceeded permissible limits therefore pose serious environmental concern. The water was classified as brackish, saline, hard, nearly polluted and not potable.

Bello *et al.,* (2013) An investigative study was carried out to determine the bacteriological and physicochemical qualities of borehole and well water samples in Ijebu-Ode, Southwestern Nigeria. Ten water samples each of borehole and well water sources were collected within the geographical location and concluded that not all borehole waters are safe for consumption and well waters were of poorer bacteriological qualities indicative of health risk to the inhabitants of the geographical location.

Wangboje and Ekundayo (2013) report on the assessment of heavy metals in surface water of the Ikpoba reservoir, Benin city, that Water samples were randomly collected from four stations within the Reservoir from August 2005 to December 2005 and were analyzed for heavy metal concentrations using Atomic Absorption Spectrometric technique. The mean concentration of these metals were, Cd, (0.02mg/L), Mn(0.026mg/L), Cu(0.24mg/L), Fe(5.60mg/L), Pb(0.07mg/L), Ni(0.03mg/L), Zn(116.59mg/L) and Cr(0.033mg/L). The mean concentrations of Cd, Fe, Pb, Ni and Zn, exceeded the World Health Organization (WHO) maximum permissible level for drinking water.

Adefemi and Awokunmi (2010) studied the Determination of physico-chemical parameters and heavy metals in water samples from Itaogbolu area of Ondo State. The results of the physico-chemical analysis were obtained in the following range; pH (6.59-7.68), temperature (21.10-27.10ºC), conductivity (300-1150 µ/cm), chloride (78.10-156.20 mg/L), total hardness (130-298 mg/L), sulphate (82.50-97.00 mg/L), TDS (0.02-0.09%) and alkalinity(0.92-2.45 mg/L). The highest value of physico-chemical parameters (compared with wells) was obtained in Ona River. The concentration of heavy metals (mg/L) in the well and Ona river samples were found in the following range; Zn (5.5-9.2), Cr (ND-0.4), Pb (ND-0.2),Cu (ND-0.4), Ni (ND-0.1) and Fe (0.1-5.3). Cadmium was not detected at all in all water samples. The results obtained fell within the maximum allowable limit set by World Health Organization for drinking water except for water from Ona river.

Oyeku and Eludoyin (2010) studied Heavy metals contamination of groundwater resources in a Nigerian urban settlement and The study showed that the groundwater in the study area were generally alkaline (8.3 ± 2.77) and contained Cu (0.02 ± 0.04 mg/L), Fe (4.23 ± 6.4 mg/L), Pb (2.4 ± 3.3 mg/L) and Co (1.03 ± 1.1mg/L) concentrations that are higher than the permissible limits recommended by the World Health Organization (0.5, 0.1, 0.01 and 0.0002 mg/L, respectively; $p > 0.05$). The study concluded that the groundwater sources within 2 km radius of a major landfill will be vulnerable to the effect of landfill, if they are not adequately protected.

MATERIALS AND METHODS

SAMPLE TREATMENT

The sampling was carried out in Dutsinma Town, Katsina State, Nigeria. The water samples were collected and stored as follows;

SAMPLING TECHNIQUE

Random sampling technique was used in selecting the water samples; the wards/areas were divided into four regions (Kadangaru , Unguwar Kudu , Unguwar Yamma and Hayin Gada). In each area, two bore hole were selected at random.

SAMPLE COLLECTION

The water samples were collected from Eight boreholes, within Dutsinma metropolis. The samples were collected in a clean 2.0L sample bottle and labeled as follows;

Location/Sample	Level
Kadangaru Borehole Water Sample	A1
	A2
Unguwar Kudu' Water Sample	B1
	B2
Unguwar Yamma Water Sample	C1
	C2
Hayin Gida Bore hole Water Sample	D1
	D2

SAMPLE STORAGE

The water samples were stored in the laboratory refrigerator in order to prevent change in its chemical composition; the samples were stored for a period of 48 hours.

Determination of pH

The borehole Water samples was transferred into a clean dried glass beaker, then the electrodes of standardized pH meter was immersed and the meter was allowed to standardized, after which the reading was taken. The electrode was rinsed well with distilled water and tabbed slightly with tissue paper after each test as described by Geotechnical Engineering Bureau, 2007

3.3.2 Determination of Turbidity

The sample of the bore hole water was transferred into the sample cell turbidity meter up to the horizontal mark, then wiped with tissue paper and subsequently placed in the turbidity meter such that the vertical mark in the sample cell coincide with the mark in the turbidity meter, after which it was covered. The readings displayed on the screen and was recorded, as described by NITTRC, 2009.

3.2.7 Determination of TDS

The TDS of the bore hole water samples were analysed using TDS meter. The sample will be put in a clean beaker and the head of the TDS meter was immersed in the beakers. Readings were taken as described by (APHA 2005).

Determination of Presence of Coliforms Bacteria

The bacteriological analysis for the 8 bore hole water samples were analyzed using most probable number method (MPN method),The analyses was carried out to determine whether there was a presence of coliforms bacteria in the bore hole water samples The procedures of APHA , 2005

(i). 100g of Macconkey broth media was taken, weigh and dissolved in 1200ml of distilled water.

(ii). 10 ml of the prepared broth media was dispensed in each of the 120 bottles (15 bottles for each sample)

(iii). The 120 bottles with prepared media dispensed, were sterilized for 20 minutes at 121 degrees Celsius of temperature. This is to destroy all microorganisms present.

(iv). For the first sample, 10 ml of the water sample was dispensed for the first set of five bottles, then 1ml of the water sample was also dispensed in second sets of five bottles, then 2 drops of the water sample was dispensed in the third set of five bottles. This procedure was repeated for all the remaining 7 samples.

(v). The bottles were then incubated at 37 degrees Celsius for 48 hours.

Observation: Colour change from red to orange was observed and recorded for each of the sets of samples

Conclusion: The number of bottles which changed colour will be counted and interpreted using MPN(most probable number) table.

Determination of total hardness

2ml of ammonia buffer solution and 1 tablet of Erichrom black T was added to each of the 100ml of the samples of the bore hole water. The mixture was titrated against EDTA, until a blue end point was observed (APHA, 2005).

Determination of chloride

2 drop of potassium chromate indicator wasvadded to each of the 100ml of the bore hole water samples and titrate with 0.01N AgNo3, until pinkish yellow colour was observed. The PH of the water samples can be adjusted down with dil. H2SO4 (if not between 7 and 10). Or adjusted up with 2N NaOH (if not between 7 and 10) (APHA, 2005).

SAMPLE DIGESTION

5.0ml of nitric acid was added to 100mL of water sample in 250mL conical flask, the mixture was evaporated to half of its volume on a hot plate after which it was allowed to cool and then filtered (Momodu *et al.,* 2009).

SAMPLE ANALYSIS

The digested water samples were analysed for the presences of lead (Pb), Manganese (MN), Nickel (Ni), Cadmium (Cd), Cromium (Cr) , Arsenic (Ar) , Zinc (Zn), Iron (Fe), and Copper (Cu). Using atomic absorption spectrophotometer. The concentrations of such heavy metals were calculated using the standard calibration plot of each metal (Momodu *et al.,* 2009).

Table 1 . Results for Physical Analyses

Sample	pH	Turbidity(NTU)	TDS(mg/L)	Conductivity	Colour
A1	7.01	2.05	42	67	5
A2	6.95	2.11	45	66	5
B1	7.21	1.39	56	63	10
B2	7.20	1.36	58	63	10
C1	6.92	1.96	64	61	5
C2	6.98	1.90	67	59	10
D1	6.86	4.35	51	72	5
D2	6.93	3.98	49	74	5

Table 2. Results for Chemical Analyses

Samples	Total Hardness(mg/l)	Calcium Hardness(mg/l)	Magnesium Hardnes(mg/l)	Chlorides(mg/l)	Salinity(mg/l)
A1	25.50	15.40	10.10	4.80	07.92
A2	25.50	16.90	08.60	4.79	07.90
B1	18.60	12.40	06.20	6.40	10.73
B2	18.20	14.10	04.10	6.35	10.48
C1	23.60	17.30	06.30	7.85	12.95
C2	23.00	15.60	07.40	7.60	12.54
D1	29.00	19.10	09.90	6.30	10.40
D2	29.50	18.50	11.00	6.20	10.23

Table 3 . Results for Heavy Metals Analyses

Sample	Lead(Pb)	Manganese	Nickle(Ni)	Cadmium	Chromium	Arsenic
A1	0.02	0.00	0.00	0.00	0.00	0.00
A2	0.01	0.00	0.01	0.00	0.00	0.00
B1	0.20	0.01	0.00	0.00	0.01	0.00
B3	0.28	0.01	0.00	0.00	0.00	0.00
C1	0.32	0.00	0.01	0.00	0.00	0.00
C2	0.30	0.00	0.01	0.00	0.00	0.00

D1	**0.01**	**0.00**	**0.01**	**0.00**	**0.01**	**0.00**
D2	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**

Table 4. Results for Bacteriological Analyses

Sample	10mg/l	1mg/l	0.1mg/l	MPN
A1	0	0	0	2
A2	0	0	0	2
B1	1	0	0	2
B2	0	0	0	2
C1	1	0	0	2
C2	0	0	0	2
D1	0	0	0	2
D2	0	0	0	2

HEAVY METALS

3.2.1 Lead (Pb)

Table 3 represent the results of heavy metal concentrations in each bore hole water sample. The concentration of lead in borehole water recorded were : 0.02 , 0.01, 0.20 , 0.28 , 0.32 , 0.30 0.01 and 0.01(mg/L) for A1 , A2 , B1, B2 , C1 , C2 , D1 and D2 respectively. The concentrations of B1 , B2 , C1 and C2 are within the maximum permissible limit set by WHO (2011) and SON (2007) which is 0.01mg/L , while A1 , A2 , D1 , D2 are not within the limits sets . Even though WHO (1971) set 0.1mg/L, . Also , The values of the concentration of manganese in the borehole water recorded were : 0.00, 0.00 , 0.01 , 0.01 , 0.00 , 0.00 , 0.00 , 0.00(mg/L) for A1 , A2 , B1, B2 , C1 , C2 , D1 and D2 respectively. The concentrations of B1 , B2 , C1 and C2 are within the maximum permissible limit set by WHO (2011) and SON (2007) which is 0.01mg/L , while A1 , A2 , D1 , D2 are not within the limits sets . Even though WHO (1971) set 0.1mg/L. Also the results for the concentration of Nickel recorded were 0.1mg/L for A2 , C1, C2 , D1 and D2 respectively , while 0.0mg/L was recorded for A1 , B1 and B2.There was no concentration of Cadmium and Arsenic recorded for all the borehole water samples. While only 0.01mg/L were recorded as concentration of Chromium for B1 and D1 , and 0.00mg/L for the rest of the water samples.

CONCLUSION

This study assessed the quality of borehole water in Dutse Metropolis and has revealed that; Due to less industrial activities which can lead to the disposal of pollutants contaminants and the natural filtration process of the soil and weathered material that, the water undergoes; by the time it reaches the water table it will become of good quality. On comparing results of the analysis for pH, turbidity, alkalinity, TDS, total hardness, calcium hardness, magnesium hardness conductivity, chloride and heavy metals with the WHO and SON standards for drinking water, all the above mentioned parameters are below the maximum permissible limits. This suggested that the water is of good quality for human consumption and other domestic uses.

The results obtained for Lead (Pb) and Cadmium (Cd) heavy metals concentration are above the limit set by WHO and SON while the results obtained for Zinc, Copper and Iron are within the standard limit set by WHO and SON. A good treatment is required in order to reduce the concentration of Lead and Cadmium in borehole for the water to be of good quality.

RECOMMENDATIONS

The supply of adequate clean water for human consumption should be of priority to any government that wants to improve the quality of life of its populace. In this regards, the present study assesses the quality of borehole water in Dutse Metropolis, it is recommended that;

Good treatment is needed in order to reduce the concentration of the heavy metals in the water.

More and regularly researches (especially on heavy metal contaminations) are needed in this field in order to prevent ourselves from the effect of these water pollutants.

The government and water supplier’s body should give more emphasis on the disinfection process in order to provide a drinking water of best quality.

The water supplier’s body (including water board) and all the people in the region should give more concern on regular cleaning the water storage containers or system, since minor presence of bacteria in distribution systems and stored water supplies can reveal regrowth of the bacteria and other organisms.

Also, an environmental awareness association(s) should regularly organize a programme in order to educate members of the community on the proper disposal of waste, management and protection of their water resources. These would drastically reduce acute problem of water pollutants and water related diseases, which are endemic to the health of man.

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