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Effect Of Drillingand Development Methods On Borehole Water Quality In Numan Local Government Area Of Adamawa State, North Eastern Nigeria

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ABSTRACT: This study was carried out in Numan local government area of Adamawa state, Nigeria and was conducted to assess the water quality of both mud and air rotary drilling methods in Numan local government area of Adamawa State in order to determine the effects of drilling methods and development on water quality of the boreholes. Twenty boreholes (20) were identified: ten (10) each mud drilled and ten air rotary. Data on boreholes parameters (depth, yield etc.) were collected and a total of twenty (20) water samples were collected and taken to the laboratory for analysis using standards method. The studywas limited to the evaluation of water quality of the boreholes drilled in Numan Local Government Area of Adamawa State using the two methods only. The result indicates that there was no contamination of the borehole water drilled using the air rotary drill but for the mud drill method pollutants were contained in the water. The mud drill method borehole contains 3.1 Mg/l of Calcium Carbonate which is the major chemical constituents of bentonide and 1.4 Mg/l of grease and oil.

KEY WORDS: Drilling, Development, Borehole and Water Quality.

I. INTRODUCTION

1.2 Background of the study

Water is essential to the survival of humanity because it is important for body function. Water makes up about 75% of the total body weight (WSSC 2004; WHO, 2011). Lack of water can lead to serious implication such as Hypertension, high cholesterol, and heart diseases. Recent studies have also linked headaches, arthritis, and heartburn to lack of water (Foster et al, 1998 and Jain et al, 1996, 1995). Therefore, it is recommended that one should drink at least 20 liter of water per day (WHO, 2010). However, despite the need to ensure sufficient water both in quantity, one of the biggest developmental challenges is the ensuring of sufficient water quality (Ishaku et al, 2000; Eziegboet. al,2013 and Sangodoyin,1987, 1989). Providing safe water is one of the most challenging task facing Nigerian water sector agencies and Numan LGA in Adamawa state is not an exception.

In recent times, water provision shows that 900 million people worldwide do not have access to potable water supply. Of these 84% live in developing nation (WHO/UNICEF 2010). Although the world as a whole is making progress towards achieving the millennium development goal (MDG) target of 50% access to portable drinking water by rural communities by 2015, quite a number of percentage proportion of the population are still not having access to sustainable safe drinking water and this is still far fetch. Boreholes are the major source of portable water for household communities, institution and industries in the country and Numan Local Government Area is not an exception. Methods of boreholes drilling are mainly air rotary and mud drill which are widely used. So far no attempt has been made to assess the effect of the drilling methods and development on borehole water quality. This study evaluates the effect of the two drilling methods and developmentcommonly used in Numan Local government Area Adamawa State on borehole water quality.

1.3 Air Rotary Drilling Method

The air rotary drilling method usescable tool drills by lifting and dropping a string and tool

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suspended on a cable. A bit is attached to the bottom of the tool and it strikes the bottom of the hole, crushing, breaking and mixing the cuttings. A string of tool in ascending order consists of a bit, a drill stem, jars and swivel socket which are attached to the cable. The cable tool method of drilling often referred to as the standard method, churn drill, percussion method as the yo-yo is one of the oldest most versatile and simple drilling devise, (Todd, 1980).This method in recent technology has been developed to use compressed air for the removal of the cuttings in the hole and thus named air rotary drill.

1.4 Mud Drilling Method

The mud method of drilling is a process in which a hole is drilled into the ground by rotating a drill stem with a bit attached to its end. As the bit is rotated, it loosens and removes rock chips and cuttings and simultaneously a circulating fluid is forced down inside the hole of the pipe (Papp, 2001, Sadiqet al. 2003). The water pumped under pressure thus clears the hole. If the water is used as the circulating fluid, it flows from the annulus to a settling pit where the fluid is picked up at the pump suction and re-circulated. A drill stem consist of a bit drill collars stabilizers and a drill pipe. Bit selection depends on the anticipated formation to be encountered and on the high strata identified in the geophysical survey.

Mud and air rotary drilling methods are the two common methods of boreholes drilling in Numan Local government Area Adamawa state. The quality of the borehole water, however, needs to be evaluated because of possible contamination due to chemicals, oil and grease hence the study. This study is limited to the evaluation of the water quality of boreholes drilled in Numan Local Government Area of Adamawa state by mud and air rotary drilled methods only.

1.5 Ground Water Quality

The quality required of a ground water supply depends upon its purpose, (Adekeye et al, 2004; Yenika et al, 2003 and Yusuf, 2007). Thus, the needs for drinking, industrial and irrigation water very widely. In establishing quality criteria measures of chemical, physical, and bacteriological constituents must be specified as well as standard methods for reporting results of water analysis,(Alexander,2008; Ishaku et al, 1995 and Malgwi et al,1991). Recommended limits of water quality can then be used to serve as guides for interpretation of resultsof ground water quality in a basin.

Table1: Major and Minor Physiochemical Constituents of Ground Water
Source: www.wikipedia.com

Cations	Anions	Metals/Others
Calcium (Ca)	Carbonate (CO3)	Iron (Fe)
Magnesium (Mg)	Bicarbonate (HCO3)	Aluminium (AL)
Sodium (Na)	Sulphate (SO4)	Silcate (SiO2)
Potassium (K)	Choloride (Cl)	Boron (B)
	Nitrate (NO3)	Fluoride (F)
		Selenium (Se)
		Copper (Cu)

1.6 Development Methods

There is only one standard development method of well development which combines several processes and procedure. The purpose of borehole development is to obtain maximum efficient yield of borehole. Incidental its benefits which include stabilization of the structure, minimizing of sand pumping, and the improvement of corrosion and encrustation conditions, (Todd, 1980). Development also removes the cake from face of the borehole and breakdown the compacted annulus about the hole caused by drilling. Development removes the fines from the aquifer. The method involves using water to surge back and forth through the screen. Gravel packing the aquifer to aids the flow of water into well at higher velocities than during pumping at design rate. Materials which are brought to stability under high development velocities and surging will remain stable under velocities during normal pumping operation.

Proper and careful development well or borehole will improve the performance of most well or borehole. Well development is not expensive in view of the benefits derived and only under unusual circumstance or improper method will it cause harm.

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II. MATERNAL AND METHODOLOGY

2.1 Study Area

Numan is a town and a Local Government Area in Adamawa State, Nigeria. The town lies between the coordinates of 9^0 28^1 N and 12^0 E and it is located about 45km from Yola, on the confluence of the Benue River, (Adamawa Diary, 2015)

2.2 Methodology

Purity of drinking water from different drilling methods remains questionable. In a bid to ascertain the health risk local people are exposed to, this study analyzes the effect of drilling methods and development on borehole water quality in Numan Local Government Area (LGA) of Adamawa state, Nigeria.Reconnaissance survey was followed by data collection on location of boreholes and investigation of drilling methods and development of boreholes within the area of study.Two methods of drilling were used for the purpose of this study. Samples from both methods were collected.A total of twenty (20) boreholes were identified and ten (10) samples each were collected for air drill mud drilling method respectively. Samples were properly labeled and transported to the Geology laboratory of the Federal University of Technology (FUTY), Yola.

2.3 Water Sampling of Borehole water from Mud Drilling Method.

The ground water sampling was carried out after it has been pumped for fifteen minutes in order to have good representative samples, not a sample of stagnant or point water . Also during the water sample collection the 1.5 liter plastic bottle was rinsed with the water being sampled. The sample was then securely corked, stored in cool place and transported immediately to laboratory for analysis using standard laboratory methods, (Page et al, 1982; U S Salinity laboratory, 1984).

Samples of ground water were collected after hand pumping of boreholes sunk by UB and Lawrenag Water Engineering Services Ltd using mud drill method, (UB Waters, 2013). The borehole was hand pumped for fifteen (15) minutes.Plastic bottles of 1.5 liter were filled and tightly capped, labeled and transported to the laboratory for physiochemical analysis.

Well location, depth, size of casting, date, water temperature, odour, colour, turbidity and operating condition of the well prior to sampling were noted.Table 2.1 indicates location/borehole data and distribution of samples collected from the mud and drill method and air rotary drill methods.

Table 2.1: Borehole Data and SampleDdistribution

Borehole No.	Location	Depth of Boreholes (m)	Static W/l (m)	Discharge (Q) (1/s)	Remarks
1	Dorawa I	24.9	7.83	0.3	,,
2	Dorawa II	60.0	4.0	0.3	,,
3	HayinGaba	47.50	5.35	1.5	,,
4	Imbru	45.00	3.10	1.7	,,
5	Kilan	26.60	4.08	0.68	,,
6	Kodomti	27.2	10.4	1.3	,,
7	Kwapuke	36.7	2.41	1.05	,,
8	Ngblang	35.25	3.00	1.15	,,
9	Nzoruwe	35.10	0.2	0.25	,,
10	Pullum	17	2.52	2.52	,,
11	Shafforon	30.15	2.00	0.354	Air Dril
12	PegiNgbalang	30.0	2.5	1.5	,,
13	S/PegiNgbalang	40.16	3.50	0.24	,,
14	PegiNgbalang	32.40	3.06	0.4	,,
15	Zambun	35.00	2.21	1.2	,,
16	Zangun	28.3	3.0	0.5	,,
17	Kpali	30.30	8.37	0.5	,,
18	Opalo	30.00	1.83	0.65	,,
19	Oversear	25.4	7.7	0.28	,,
20	Numan Town	30.6	6.80	0.38	,,

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2.5
Water Quality Parameters

The samples were analyzed for the following parameters, PH, Total hardness (TH), Total Dissolved Solid (TDS), Alkalinity, Conductivity, while Colourand odour were observed. Total Hardness (TH) is a measure of the calcium and magnesium content and is commonly expressed as the equivalent weight of calcium carbonate, (U S Salinity Laboratory staff, 1984). Thus;

$$TH = Ca \times \frac{CaCO^{3-}}{Ca} + Mg \times \frac{CaCO^{3-}}{Mg}$$

Where TH is measured in ppm of $CaCO^{3,}$,Ca and Mg in ppm and the ratios in equivalent weights.

Determination of total dissolved solid (TDS) was carried out by measuring the electrical conductivity (ECw) of the ground water; samples were reported and discussed. Other parameterswere determined using standard laboratory methods.

III. RESULTS AND DISCUSSION

3.1 Physical Properties of Water

Physical properties of water were observed for the following parameters as indicated in table 3.1

Table 3.1: Physical Parameters of Water Samples for Mud Rotary Drill.

BH No.	PH	Colour	Taste	Odour
1	6.97	Clear	Tasteless	Odourless
2	6.78	Clear	Tasteless	Odourless
3	6.80	Clear	Tasteless	Odourless
4	6.40	Milky	Salty	Odourless
5	7.11	Clear	Tasteless	Odourless
6	7.88	Clear	Tasteless	Odourless
7	7.10	Clear	Tasteless	Odourless
8	6.50	Clear	Tasteless	Odourless
9	6.52	Clear	Tasteless	Odourless
10	6.70	Clear	Tasteless	Odourless
WHO Limit	6.5-8.5	Colourless	Tasteless	Odourless

Table 3.1 above, indicates that sample Borehole No 4 falls outside WHO limit for drinking water quality standards. Physical properties of water samples from air rotary drill method were carried out by mere observation for the parameters indicated in table 3.2

Table 3.2: Physical Parameters of Water Samples for Air Rotary Drill.

BH No.	PH	Colour	Taste	Odour
1	8.40	Clear	Tasteless	Odourless
2	7.82	Clear	Tasteless	Odourless
3	6.88	Clear	Tasteless	Odourless
4	7.01	Clear	Salty	Odourless
5	8.13	Clear	Tasteless	Odourless
6	6.90	Clear	Tasteless	Odourless
7	6.76	Clear	Tasteless	Odourless
8	8.45	Clear	Tasteless	Odourless
9	6.52	Clear	Tasteless	Odourless
10	7.33	Clear	Tasteless	Odourless
WHO Limit	6.5-8.5	Colouless	Tasteless	Odourless

Table 3.2 above, indicates that all water samples of the boreholes falls within WHO limits and standards for drinking water quality.

3.2 Physiochemical Parameters of Water Samples

3.2.1 Air Rotary Drilled Boreholes

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Results from the air rotary drill indicate that there is no contamination of the borehole water and it also met the standards of the water quality guidelines of WHO, (1990, 2011 and SON, 2007). Table 3.2.1 shows the results of physiochemical properties of samples of water from boreholes drilled by air rotary drilling methods.

Table 3.2.1: Physiochemical Properties of Water Samples from Air Rotary Drilling Method

BH No.	TDS (Mg/L)	Ca (Mg/L)	Mg (Mg/L)	Na (Mg/L)	HCO3 (Mg/L)	C1 (Mg/L)	SO4 (Mg/L)	Na %	EC_w µs/dm3	Remarks
1	0.13	1.41	0.44	0.89	1.88	0.34	0.33	33	250	Good
2	0.10	0.21	0.05	2.42	1.20	0.68	0.67	90	240	Good
3	6.90	0.24	0.02	7.28	2.39	2.47	2.48	96	320	Good
4	0.57	2.49	5.81	2.83	8.87	1.13	1.02	25	245	Permissible
5	0.90	1.20	2.00	8.10	8.10	1.00	2.60	72	252	Permissible
6	0.25	8.30	0.75	3.96	2.46	2.73	4.47	30	432	Good
7	0.71	2.14	0.08	12.67	1.02	12.04	1.80	85	455	Good
8	0.50	11.40	5.70	12.90	2.80	2.80	23.00	45	243	Permissible
9	1.65	12.37	16.71	27.75	8.55	8.55	41.74	49	342	Good
10	3.41	9.54	14.23	32.52	9.43	9.35	44.19	52	244	Permissible
WHO Limit	1000	200	200	200	250	200	250	25	1000	-

3.2.2 Physiochemical Properties of Water Samples from Mud Drilling Method

Results of water samples from the mud drilling method indicate that calcium ions ($Ca^{2+}Mg^{2+}$) are slightly high in boreholes nos 7, 8, 9, and 10.but not above the limits and standards of UNICEF and WHO, (2004). This could be attributed to the chemical used (Bentonide) in mud drilling method. Also, the result indicates that328.24Mg/l of sodium was detected in borehole no 10. This is probably due to the parent rock materials. Traces of grease and oil were found in the water samples of boreholes nos 2 an3 3.

Table 3.2.2:Physiochemical Parameters of Water Samples from Mud Drilling Method

BH No.	TDS (Mg/L)	Ca (Mg/L)	Mg (Mg/L)	Na (Mg/L)	HCO_3 (Mg/L)	C1 (Mg/L)	SO_4 (Mg/L)	Na %	EC_w µs/dm^3	Remarks
1	0.14	1.31	0.55	0.82	1.99	0.20	0.65	31	243	Good
2	0.11	0.24	0.04	2.41	1.30	0.86	0.34	79	543	Unsuitable
3	6.30	0.21	0.02	6.38	2.39	2.47	2.81	86	231	Unsuitable
4	0.47	2.54	5.32	1.94	8.82	1.18	1.01	28	345	Permissible
5	0.56	1.28	2.02	8.10	7.10	1.00	2.40	75	212	Doubtful
6	0.22	8.29	0.71	3.89	2.56	2.73	3.47	30	417	Permissible
7	0.75	22.17	0.09	12.71	1.09	12.01	1.80	82	233	Unsuitable
8	0.50	11.13	5.60	12.60	2.84	2.73	21.03	41	235	Doubtful
9	1.60	12.47	15.39	26.72	2.57	7.88	41.74	50	413	Unsuitable
10	1.46	14.25	15.56	328.34	3.56	8.24	50.27	60	253	Doubtful
WHO Limit	1000	200	200	200	200	250	250	25	1000	-

3.3 Bacterial Analysis

Bacteriological analysis was not conducted due to the fact that borehole water is usually safe from bacteria due to depth of aquifer filtration and temperature that water passes through during deep percolation..

IV. CONCLUSION

This study was conducted to assess the effect of drilling methods and development on borehole water quality in Numan Local government Area of Adamawa State, Nigeria. The study showed a significant variation among the different methods in some of the parameters evaluated. In most of the water samples the air rotary drilling method is considered tobe the most suitable method for good drinking water quality for

domestic uses. Sampling and analysis for physical and physiochemical properties were analyzed using standard methods and techniques. The water samples from the mud drilling method were found to contain some traces of bentonide and Carbonyl Methyl cellulose (CMC) which are chemicals used in mud drilling fluid.

The physiochemical analysis carried out in the Laboratory of the Geology Department, FUTY, Yola, indicates that values for Ca^{2+} and Mg^{2+}, $CaCO_3$ and Cl^-arewithin the range of WHO limits and standards for all the water samples from air rotary drilling method. Also the result shows that the PH values of water samples range from acidic to partially neutral which makes the water naturally suitable for drinking. Table3.2.

The study reveals that mud drilling method water samples contains slight traces of chemicals, grease and oil. Also, one water sample was milky in colour which might be as a result of improper use of drilling chemical during drillingprocess.

V. RECOMMENDATIONS

Based on the findings from the study, the following recommendations are made:

(i) It is recommended that mud drill method of drilling boreholes must be properly developed and back washed by contractors / drillers to ensure complete removal of chemicals and mud that might contaminate the borehole water.

(ii) It is recommended that Government must ensure that all contractors drill and develops boreholes to specifications and standard before handing over to clients.

(iii) Water quality analysis and reports must accompany newly designed and drilled borehole in Numan Local Government Area and Adamawa State.

(iv) Legislations to en-act laws and subsequent enforcement by Adamawa State House of Assembly and relevant agencies and ministries as well as stake holders in the water sector is also recommended.

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