2nd International Civil Engineering Conference (ICEC 2020)
Department of Civil Engineering
Federal University of Technology, Minna, Nigeria

EVALUATION OF BOREHOLE PERFORMANCE IN GASHAU, YOBE STATE NIGERIA

Junias, J, S. and Saidu, M.
Department of Civil Engineering Federal University of Technology, Minna
Email: junias.mshelia@yahoo.com

ABSTRACT

Water is one of the valuable natural resources whose quality and quantity has vital concern for the human welfare. This study is aimed at evaluating the performance (yield) of selected boreholes in Gashua, Yobe State, analyse the efficiency of the boreholes and examine the physio-chemical parameters of the boreholes. A total of twenty (20) boreholes were selected in the study area. The study includes among others the determination of the general performance of the selected boreholes. Bacteriological and physio-chemical parameters analysing and investigating the various causes of their abandonment and/or poor performance of those boreholes at various locations. Result revealed that 100% of the boreholes were productive while 0% was abandoned. Among the productive ones, it was further found out that their performances on average is 35.3% efficiency for the 20 boreholes. The observed cause of low yield was due to hydrogeological, technical/constructional and operations/maintenance factors. Based on the findings, suggestions were made with a view to provide lasting solutions to the identified problems so that the supply can meet the demand of the increasing population and that of industrial and agricultural development. Also the result from bacteriological and physio-chemical properties of the boreholes were compared with WHO and NSDWQ which showed that the physio-chemical quality of water within the study area was mostly within acceptable limits. Bacteriological assessment within the study area ranged within (CFU/100ml). These results could be attributed to the activities going on in this area with respect to the presence of large scale upland and irrigated farm land which may introduce leaching fertilizer into the river so also the presence of traditional potash mining sites. Conclusively, the results of the analysis of the twenty samples from various locations in Gashua, Yobe State showed that the physical and chemical parameters of most of the water samples were within the acceptable limit of the WHO and NSDWQ. While the bacteriological parameters determined exceeded the acceptable limits, suggesting that the water samples may be contaminated bacteriologically.

Keywords: *Boreholes; Bacteriological ;Hydrogeological factor; Performance; physio-chemical;*

1 INTRODUCTION

Water is one of the valuable natural resources whose quality and quantity has vital concern for the human welfare. Groundwater is the main source of water that meets the agricultural, industrial and household requirements. The availability of groundwater depends upon the nature of rocks and their water bearing characteristics. Ground water is one of the most valuable natural resource, which supports human health, socioeconomic development and functioning of ecosystems. Many communities in Africa depend heavily on groundwater. Exploitation of surface waters has reduced, ensuring an increasing reliance on groundwater abstraction due to increasing pollution with the concomitant rise in the cost of water treatment (Adekola, 2015). In Nigeria, about 65% of total populations rely heavily on groundwater for drinking purposes (Edmunds et al., 2008; 2009).

Quality should generalize how substantially a water supply fulfils the needs of the planned user and must be assessed based on its suitability for the proposed use (Ayers and Wert scot, 1985). The quality of water focuses on its suitableness for use. Maximum yields can be obtained if the water quality is good under proper soil and management conditions.

Suitability of water for various uses depends on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water (Omotayo et al., 2017). Groundwater assessment for drinking and irrigation has become necessary and important task for present and future groundwater quality management. Nowadays, a lot of studies have focused on groundwater quality monitoring and evaluation for domestic and agricultural activities around the world. When the heavy metals exceed maximum permissible concentration for potable water, the water is said to be contaminated (Izah and Ineyougha, 2015). Water is life, it is vital to all forms of life on earth. Provision of fresh water to drink, for use in industry, agriculture and for the multitude of other purposes is necessity (UNESCO, 2012).

Provision of an adequate quality of water has been a matter of concern since the beginning of civilization. Before 1920's groundwater withdrawal in the lake Chad Basin in Nigeria was effected only through the traditional methods which include unlined wells dug by the inhabitants. However, this source did not meet the demand of the population of the study area because almost all of unlined wells dried up as a result of depletion in water table. Due to this unreliability and difficulties of the traditional sources faced by the inhabitants of the area, groundwater development was started in the 1920s and subsequently, boreholes were drilled to various depths within the underlying aquifers (Ndubuisi, 1990).

More exploitation of these aquifers continues with the establishment of the Chad Basin Development Authority (CBDA) in the 1970s. At present, several additional agencies such as the Agricultural Development Programme, Local Governments, individuals, NGOs, and private companies are involved in sinking boreholes (Ndubuisi, 1990). Development in groundwater resources appears to be the most important water resources development strategy in the Arid Zone of Nigeria. This is particularly because of the apparent absence of perennial streams and the hot climate condition characterizing the area which may have adverse effect on other water resources development attempts. For this reasons hundreds of boreholes and wells have been sunk sometimes to great depths to tap groundwater. Like surface water, development in groundwater resources in the Arid Zone of Nigeria has over the years constituted some environmental problems to the area. Groundwater development in this zone has led to over abstraction of groundwater over recharge. A continued abstraction over recharge borehole may lead to complete depletion of the groundwater resources and consequently the people of the Arid Zone, who mainly depended on groundwater may be in trouble. In addition to the apparent fall in the groundwater table continued abstraction over long period of time may also lead to a reduction in the aquifer capacity.

Thus, studies on the qualitative and quantitative evaluation of boreholes performance is necessary if the water supply demand is to be met sufficiently.

2 METHODOLOGY

2.1 THE STUDY AREA

Gashua is a community in Yobe State in Northeastern Nigeria, on the Yobe River a few miles below the convergence of the Hadeja River and the Jama'are River. It is the headquarters of the Bade Local Government Area and is one of the largest and most developed towns in Yobe State. The average elevation is about 299 m. The population in 2006 was about 125, 000. The hottest months are March and April with temperature ranges of 38 - 40 ºC. In the rainy season, June - September, temperatures fall to 23 - 28 ºC, with rainfall of 500 - 1000 mm. Gashua belongs to semi-Arid region, with limited surface water which brings a great dependence on groundwater. Access to portable water commodity for domestic and irrigation purposes are majorly through digging wells and sinking boreholes. Gashua town is located between latitude 12o 52' 5" North and longitude 11° 2' 47" East.

2.2 METHOD OF DATA COLLECTION

The method of investigation adopted for this work involves collection of information on the general performance of boreholes within Gashua, Yobe State from the Yobe State Water Board Corporation (YSWBC). Visits to the site of twenty (20) selected boreholes to make in-situ assessment, was undertaken. Discussions were held with the various Managers/operators of different boreholes with each having its peculiar mode of operation and problems. Water sample and discharge of each borehole was obtained as well as the operational status such as productive or abandoned. The data collected was used for determining the borehole performance, finding out problems encountered and then analyzing these problems.

2.3 LABORATORY ANALYSES

The bacteriological parameter was tested for is the total bacteria count (Total coliform, CFU/100ml and E. coli) while the physiochemical parameters measured are: pH, Electrical conductivity, calcium, magnesium, Total Dissolved Solids, Total Hardness, Iron, Sulphide, Chloride and Nitrate of the borehole water samples.

2.3.1 MEASUREMENT OF PHYSIOCHEMICAL PARAMETERS

The physiochemical parameters sited above were measured using standard procedure provided by the United States Environmental Protection Agency (US

EPA, 1996) and standard procedures prescribed by American Public Health Association (APHA, 1998).

2.3.1.1 pH

The electronic pH meter was used to measure the pH of the samples by calibrating with buffer solutions of pH 4, 7 and 9. The pH was also tested using the litmus paper to ascertain the results deduced from the pH meter.

2.3.1.2 Electrical Conductivity

In order to measure the electrical conductivity of the samples collected from the study area, the digital conductivity meter was used.

2.3.1.3 Iron

A flame-photometer was used to measure the sodium content of all the samples collected.

2.3.1.4 Calcium and Magnesium

The calcium and magnesium concentrations was measured using the Atomic Emission Spectrophotometer-Mass Plasma (AES_MP)

2.3.1.5 Chloride

Chlorides was determined by titrimetric using the silver nitrate and potassium dichromate method.

2.3.1.6 Total Dissolved Solids

The total dissolved solids were analyzed by the filtration and evaporation method.

2.3.2.7 Magnesium Hardness

Magnesium hazard of water for irrigation is calculated by the formula;

$$MH = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \times 100 \quad (1)$$

(Izah 2015)

2.4 WATER YIELD

In evaluating the yield performance of the boreholes pumping tests was carried out. The constant rate pumping test was used in conducting pumping tests on the selected boreholes.

2.4.1 Constant Rate Pumping Test

Constant rate pumping tests was conducted on the selected boreholes. The materials used for these tests include; 20-litre bucket as a standard measure, generating set to power the pump, stop watch to record time intervals and rubber hose to connect the pipe from the borehole to discharge the water into the buckets. In conducting this test, the initial or static level of the water in the boreholes was measured using a dip metre. The generating set was thereafter switched on to start the pumping. The pumping was allowed to run continuously for a long period of two hours before the rate of pumping was adjusted for the boreholes to maintain constant discharge. At this point, the water level was measured to know the drawdown and a calibrated 20 - liter bucket then filled from the constant discharge from the boreholes while a stopwatch was simultaneously set to record the time taken, in seconds, to fill the bucket. This process was repeated for four hours for each of the selected boreholes. The water level and the drawdown in the boreholes was kept constant throughout the four hours pumping. With the constant discharge from the boreholes, a state of equilibrium was maintained between the rate of discharge and the rate of recharge from the aquifer. In this condition of equilibrium, the rate of pumping or discharge was taken directly proportional to the yield of the borehole or well at the constant drawdown. In other words, the discharge per unit time in liters per second gives the yield of each of the selected boreholes at the constant drawdown.

The efficiency of the boreholes was evaluated using the equation below:

$$Efficiency, \eta = \frac{Observed\ yield}{Design\ Yield} \times 10 \quad (2)$$

(Sanyaolu, 1991)

2.5 GEOGRAPHICAL LOCATION OF GASHUA, YOBE STATE

Figure 1: Map of Nigeria Showing Yobe State

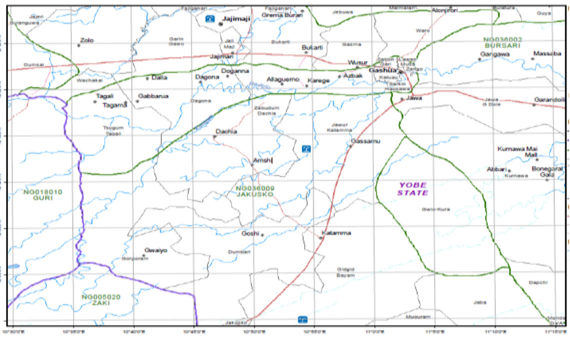

Figure 2: Map Showing Gashua, Yobe State

3 RESULTS AND DISCUSSION

3.1 Results

Table 1 below shows the result of the information of the 20 boreholes and the observed discharge for each borehole and result of the. Table 2 shows the efficiency of the boreholes from the observed and designed yields.

Table 3 shows the bacteriological and physiochemical properties of water collected from the 20 boreholes.

TABLE 1: DATA ON THE TWENTY (20) BOREHOLES CONSIDERED DURING THE STUDY (CONT.)

Constant Rate Pumping Test								
Capacity of container:20 liter bucket								
Borehole Ref	**Location**	**Borehole depth(m)**	**Average P.test**	**Average Discharge(L/S)**	**Capacity of submersible pump (Hp)**	**Draw-down**	**Duration of use Months**	**Operational status**
GB1	state lowcost	66	12.800	1.563	1.5	57	144	Productive
GB2	Biltimari	60	21.540	0.929	1	57	96	Productive
GB3	Biltimari	30	46.580	0.429	0.5	18	3	Productive
GB4	Yusufari road	60	16.520	1.211	1.5	21	84	Productive
GB5	Esari	66	14.672	1.363	1	50	96	Productive
GB6	Biltimari	66	14.180	1.41	1.5	25	72	Productive
GB7	Custom	60	20.224	0.989	2	30	240	Productive
GB8	Kabalankara	60	13.764	1.453	1.5	37	84	Productive
GB9	Karamin Tanda	66	13.642	1.466	1.5	27	24	Productive
GB10	Karamin Tanda	66	13.640	1.466	1.5	25	96	Productive
GB11	Kabala	66	13.680	1.462	1.5	29	60	Productive
GB12	Damdin PDP	60	23.550	0.849	1.5	26	72	Productive
GB13	Zangwan	60	19.426	1.03	1	21	96	Productive
GB14	Pompom kutare	60	16.690	1.198	1	17	120	Productive
GB15	Kangalapaya	60	20.220	0.989	1.5	18	72	Productive
GB16	Abasha	66	15.016	1.332	1	33	96	Productive

GB17	Fada	60	27.780	0.72	1	29	72	Productive
GB18	Fire service	60	18.376	1.088	1.5	18	108	Productive
GB19	Takari	60	13.768	1.453	1	24	156	Productive
GB20	Dawari	63	18.016	1.11	1	30	84	Productive

TABLE 2: COMPARISON OF DESIGNED AND OBSERVED YIELDS FROM THE SELECTED 20 BOREHOLES STUDIED

Comparison between Observed and Designed Yields from the selected 20 boreholes					
Borehole Ref	**Location**	**Borehole depth(m)**	**Observed Yield(L/S)**	**Designed Yield(L/S)**	**Efficiency (%)**
GB1	state lowcost	66	1.563	3.5	44.7
GB2	Biltimari	60	0.929	2.7	34.4
GB3	Biltimari	30	0.429	2.1	20.4
GB4	Yusufari road	60	1.211	3.8	31.9
GB5	Esari	66	1.363	4.2	32.5
GB6	Biltimari	66	1.41	3.8	37.1
GB7	Custom	60	0.989	2.5	39.6
GB8	Kabalankara	60	1.453	1.46	99.5
GB9	Karamin Tanda	66	1.466	2.5	58.6
GB10	Karamin Tanda	66	1.466	2.2	66.6
GB11	Kabala	66	1.462	3.2	45.7
GB12	Damdin PDP	60	0.849	4.6	18.5
GB13	Zangwan	60	1.03	3.7	27.8
GB14	Pompom kutare	60	1.198	4.1	29.2
GB15	Kangalapaya	60	0.989	5	19.8
GB16	Abasha	66	1.332	7.4	18.0
GB17	Fada	60	0.72	3	24.0
GB18	Fire service	60	1.088	4.8	22.7
GB19	Takari	60	1.453	9	16.1
GB20	Dawari	63	1.11	6.1	18.2

TABLE 3: BACTERIOLOGICAL AND PHYSIOCHEMICAL PROPERTIES OF OBSERVED BOREHOLES AS COMPARED WITH WHO AND NSDWQ

Lab ID	*Location*	*CFU/100ml*		*PH*	*EC, Ms/cm*	*Concentration in mg/l*							
		Total Coliform	*E. Coli*			*TDS*	*TH*	*Ca*	*Mg*	*Cl*	*SO₄*	*Fe*	*N*
001	State Lowcost	1.00	2.00	6.21	0.06	0.04	0.88	0.65	0.13	8.92	23.15	2.17	5.80
002	Biltimari	2.00	2.00	6.14	0.23	0.12	1.01	0.93	0.16	10.64	15.16	0.99	22.67
003	Biltimari	3.00	1.00	6.13	0.18	0.07	0.98	2.01	1.01	10.62	20.32	1.03	4.50
004	Yusufari Road	1.00	0.00	6.25	0.07	0.06	0.93	1.23	0.55	2.13	36.11	0.39	13.21
005	Esari	4.00	1.00	6.25	0.06	0.13	1.02	0.87	0.62	19.1	28.13	3.06	23.87
006	Biltimari	0.00	0.01	6.54	0.15	0.04	0.76	2.59	1.03	4.65	16.60	1.22	12.54
007	Custom	3.00	2.00	6.26	0.25	0.04	0.95	2.06	0.94		13.98	0.17	5.76
008	Kabalankara	1.00	1.00	6.29	0.14	0.11	0.83	1.12	0.57	12.19	37.61	2.96	2.28
009	Karamin Tanda	0.10	0.00	6.82	0.22	0.04	0.99	0.89	0.87	24.07	19.79	3.34	33.21
010	Karamin Tanda	2.01	1.00	6.34	0.08	0.05	0.95	0.92	0.96	3.05	32.76	2.51	4.54
011	Kabala	4.00	1.00	6.36	0.09	009	0.80	1.05	0.31	2.07	29.10	3.16	3.01
012	Damdin PDP	1.00	0.10	6.38	0.21	0.12	0.99	1.94	0.18	14.43	17.22	1.18	1.99
013	Zangwan	2.00	1.00	6.34	0.18	0.11	0.91	2.07	0.69	17.04	25.01	2.06	21.54
014	Pompom Kutare	3.00	1.01	6.35	0.15	0.04	0.72	0.73	0.15	23.65	33.19	2.90	5.76
015	Kangalapaya	2.00	1.00	6.42	0.23	0.05	0.94	2.21	1.06	4.56	20.11	1.84	31.55
016	Abasha	4.00	2.00	5.89	0.07	0.05	0.96	0.76	0.13	19.13	19.28	1.74	3.12
017	Fada	0.00	0.00	6.72	0.09	0.10	0.93	2.13	1.00	2.90	27.66	2.15	3.98
018	Fire Service	4.00	2.00	5.84	0.06	0.04	0.87	2.22	1.01	3.45	14.23	0.23	2.40
019	Takari	1.00	0.00	6.42	0.20	0.08	0.95	1.79	0.17	8.70	30.05	1.75	7.91
020	Dawari	1.00	3.00	6.41	0.16	0.06	0.92	1.90	0.61	5.56	26.59	0.98	2.87
WHO	Max. Permissible	1.00	0.01	6.5 - 8.5	2.50	1000	500	150	100	250	250	0.3	50
NSDWQ		0.10	0.01		1.00	500	150	-	20		100		

3.2 Discussion of Results

In this section the results of the bacteriological and physio-chemical parameters obtained were compared with standards from the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ). Physical parameters determined revealed that, the values for the total dissolved solids were within the WHO acceptable value of 1000 mg/L and NSDWQ of 500 mg/L, for all the twenty samples. However, water containing more than 500 mg/L total dissolved solids is not considered desirable for water supplies for drinking purposes. Electrical conductivity which is a measurement of water electrical current is directly related to the concentration of dissolved ions in the water, the value falls within the limit of WHO standard. Conductivity of the samples were on the lower side 0.06-0.23 Ms/Cm.

The pH range of (5.84-6.82) were obtained in twenty locations of the state were not all within the value of 6.5-8.5 of World Health Organization and NSDWQ standards except Karamin Tanda and Fada which had pH of 6.82 and 6.72 respectively. Calcium: 0.65 - 2.59 mg/L and magnesium, 0.13 – 1.06 mg/L were lower when compared with 250mg/L acceptable limit, Chlorides obtained were higher with values range of 2.13 - 24.07 mg/L which is above the WHO and NSDWQ acceptable value of 250 mg/L.

Iron being one of the major components of mineral element found in abundance on the earth, occurs naturally in some groundwater. The value of iron of samples were above the acceptable limits. These could cause change in colour and taste of water. Nitrate; gives 2.28-33.21 mg/l the result from all the locations are lower than 50 mg/L which is WHO acceptable value. Sulphate; 13.98 – 37.61 mg/L this is lesser than WHO and NSDWQ acceptable values of 250 mg/L and 100 mg/L respectively.

Total hardness: 0.72 – 1.02 mg/L is less than the acceptable value of 150 mg/L (NSDWQ) and 500 mg/L (WHO).

The bacteriological total coliform and the Escherichia coli presence in various water samples exceed the acceptable standard values of World Health Organization. These may lead to cases of diarrhea, cholera, fever, and stomach pain in the area. This finding agreed with EL-Ishaq *et al.* (2013), which reported the bacteriological analysis from the same state but different locations Izah and Ineyougha, (2015) review of the microbial quality of potable water in Nigeria, their study found out that the microbial load often exceeds the WHO limit of 1.0 x 10^2 cfu/ml for potable water and NSQWD maximum permissible level of 10 cfu/ml for total coliform.

The yield observed from the pumping tests was compared with the design yields of the boreholes and the efficiency of the boreholes was deduced. From the study, 17 out of 20 of the observed boreholes were below 50% efficiency as seen in Table 3 with the least efficiency, 16.2 % recorded at Takari, GB19. The highest recorded efficiency was deduced to be 99.5% at Kabalankara, GB 8. This observed failure was due to operation/maintenance and hydro-geological failures.

4 CONCLUSION

From this study the following conclusion were drawn:

I. The physio-chemical properties of the boreholes were mostly within acceptable limits, with exception like iron.

II. The bacteriological parameters of all samples were however not within the acceptable limits, these results could be attributed to the activities going on in this area with respect to the presence of large scale upland and irrigated farm land which may introduce leaching fertilizer into the river so also the presence of traditional potash mining sites. This is indicative of bacteriological contamination.

III. Result revealed that 100 % of the boreholes were productive while 0% was abandoned**.** However, it was further found out that the average performance of the boreholes was about 35.3% efficiency.

IV. The observed failures were due to hydrogeological (groundwater level fluctuation, borehole tapping aquiclude, inadequate recharge), technical/constructional (poor borehole construction and completion, improper pump selection and casing) problems and operations/maintenance (pump failure, power failure and blockage due to siltation).

REFERENCES

Adekola, S., Bashar, A. and Kasimu, A. (2015). Physio-chemical characteristics of borehole water quality in Gassol Taraba State, Nigeria. *African Journal of Environmental Science and Technology,* Vol 9(2), Pp143-154.

APHA., (1998). Standard Methods for the Examination of Water and Wastewater. 19th Edn., APHA, AWWA and WEF, USA.

Ayers, R. S. and Westcot, D. W. (1985). Water quality for agriculture. Rome: Food and Agriculture Organization of the United Nations.

Edmunds, W.M., Cook, J.M., Darling, W.G., Kinniburgh, D.G., Miles, D.L., Bath, A.H., Morgan-Jones, M. and Andrews, J.N. (1987). Baseline geochemical conditions in the Chalk aquifer, Berkshire, UK: A basis for groundwater quality management. *Applied Geochemistry*, **2**(3), 251-274.

El-Ishaq, A., Akinsola, R. O. & Mohammed, M. (2013). Determination of Quality of Portable Water in Damaturu Metropolis. *Int. J. Biol. Phy. Sci*.1(1): 006-011.

Izah, S. C. & Ineyougha, E. R. (2015). A review of the microbial quality of potable water sources in Nigeria. *Journal of Advances in Biological and Basic Research*,1(1): 12 – 19.

Ndubuisi, O. L. (1990). Managing of groundwater resource of the lake Chad basin in Nigeria. *Paper presented at the First Biennial National Hydrology Symposium, Maiduguri, Nigeria.*

Omotayo, A., El-Ishaq, A., Bafeto, M. A. & Yunusa, M. (2017). Performance of water quality parameters from five locations in Yobe State, Nigeria. *Direct Research Journal of Public Health and Environmental Technology*, vol. 2(2), pp 16-20.

Sanyaolu, O. B. (1991). Evaluation of the performance of boreholes in Maiduguri Metropolis. Unpublished B.Eng. Project, Department of Civil and Water Resources Engineering. University of Maiduguri.

SON (2007). Nigerian Standard for drinking water quality, Nigerian Industrial Standard, NIS 504, Standard Organization of Nigeria, Lagos, 2007.

UNESCO (2012). Managing Water Under Uncertainty and Risk — The United Nations World Water Development Report 4 Volume 1. Published in 2012 by the United Nations Educational, Scientific and Cultural Organization 7, place de Fontenoy, 75352 Paris 07 SP, France.

Water, Y. (1996). Yobe State Water Corporation Document. Damaturu: Yobe State Government Printing Press.

WHO/UNICEF. (2010). *Joint Monitoring Programme (JMP) for Water Supply and Sanitation*, Available from:http://www.wssinfo.org (accessed 1st June 2012).

WHO., (2011). Guidelines for Drinking Water Quality. 3rd Edn., World Health Organisation, Geneva, Switzerland, pp: 296-459.

ISSN26724391