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EVALUATION OF BOREHOLES PERFORMANCE IN MAIDUGURI METROPOLITAN, BORNO STATE-NIGERIA

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ABSTRACT

Water is life as an adage saying, therefore reliable water source is necessary for development. This study aimed to evaluate the performance (yield) of some selected boreholes in Maiduguri metropolitan, and analyze (identify) the factors responsible for low yield and failures of the boreholes. A total of fifty (50) boreholes were selected in the study area. The study includes among others the determination of the general performance of the selected boreholes, analyzing and investigating the various causes of their abandonment and/or poor performance of those boreholes at various locations. Result revealed that 64% of the boreholes were productive while 36% were abandoned. Among the productive ones, it was further found out that their performances were above 50% efficiency. The observed failures were 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 failures so that the supply can meet the demand of the increasing population and that of industrial and agricultural development.

Keywords: Boreholes; Performance; Productive: Failure; Hydrogeological factor.

1 INTRODUCTION

Water is a unique essentials resource that has no substitute (Dorglas *et al.*, 1979; Hamith and Bell, 1986). Its quantity varies from place to place and from time to time. For most places, the amount of water accessible to man is limited while, the demand for it is increasing daily (Bunu, 1990). It is against this background that the development of water resources becomes necessary so as to meet the demand of the growing population and that of the subsequent growth of industry and agriculture. Water supply within Maiduguri Metropolis is mainly dependent on groundwater due to acute shortage of surface water such as rivers and lakes which remain dry for most parts of the year. Groundwater within the metropolis is tapped through mainly hand-dug wells and by means of mechanised pump-equipped boreholes. The water supply process has the following activities; geophysical investigation, drilling, boreholes development and testing, pump installation and maintenance (Hamith and Bell, 1986; Chishti, 1990).

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 Borno State Water Board Corporation (BSWBC) and 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). As at now, the total number of boreholes sunk within the Maiduguri metropolis is over one hundred and fifty. This figure includes both the productive and the abandoned 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 characterising 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. Studies conducted in 1988 on 43 boreholes in the Maiduguri revealed that there is an annual decline in the water table of the lower aquifer to about 4.2 m (Water, 1996). 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. Studies have shown that the first two out of the three aquifers of the Chad Basin in the Maiduguri area are no more capable of providing adequate water supply (Nazir, 1979; Water, 1996). 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.

A borehole, to a Groundwater Engineer, is defined as a hole usually vertical, excavated in the earth to bring groundwater to the surface (Todd, 1923). Pumps must be installed in boreholes except where the pressure of water is sufficient to force it to the surface producing a flowing artesian (Todd, 1923). Bunu (1990) defined borehole as a hole drilled by percussion or rotary tools mechanically operated for the purpose of exploring groundwater. Borehole is also defined as a hydraulic structure which when properly designed and constructed permits the economic withdrawal of water from an aquifer, it is a narrow well, drilled with machine, more costly than hand-dug wells, but deeper and reliable (Nazir, 1979; Sanyaolu, 1991).

This study is aimed at evaluating the performance (yield) of some selected boreholes in Maiduguri metropolitan, and analyze (identify) the factors responsible for low yield and failures of the boreholes.

2. MATERIALS AND METHODS

2.1 The Study Area

Maiduguri Metropolis is a local government area in Borno State, located at North-Eastern part of Nigeria, it is bounded at the North, West and South by Jere local government council and at the East by Mafa local government area. Rainfall is generally low averaging 650 mm while temperature is generally high with a mean value of 34.80 °C. Maiduguri Metropolis belongs to semi-Arid region, with limited surface water which brings a great dependence on groundwater. Access to portable water commodity is through digging wells and sinking boreholes. Maiduguri Metropolitan occupies a land area of 300 km^2 and is located between latitudes 11^o 46", and 11° 53" North and longitudes 13° 05" and 13° 14" East (Sanyaolu, 1991).

2.2 Method of Data Collection

The methods of investigation adopted for this work involved collection of information on the general performance of boreholes within Maiduguri Metropolis from Borno State Water Board Corporation (BSWBC) and visits to sites of some selected boreholes. At the Borno State water corporation, information on the various boreholes and their performance was obtained. Visits to the site of some boreholes to make in-situ assessment, were undertaken. Discussions were held with the various Managers/operators of different boreholes with each having its peculiar mode of operation and problems. The discharge of each borehole was obtained as well as the operational status such as productive or abandoned. The data collected were used for determining the borehole performance, finding out problems encountered and then analysing these problems. Furthermore the results obtained were subjected to statistical analysis and interpretations in accordance with Alan and Keith (1943).

The efficiency of the boreholes was calculated using the formula:

$$n = \frac{observwd\ \ yield}{Designed\ \ yield} \text{x} 100\% \quad (1)$$ (Sanyaolu, 1991)

3 RESULTS AND DISCUSSION

Table 1 shows information on the fifty (50) boreholes considered during the study. Results showed that thirty two (32) are productive while eighteen (18) have been abandoned. This can be equated to a success rate of sixty four percent (64%) or failure rate of thirty six percent (36%). Out of the eighteen (18) abandoned boreholes three (3) were due to technical reasons while fifteen (15) were as a result of hydrogeological failure. These represent 16.67% and 83.33% of the total failures respectively.

Table 2 shows the comparison between the designed and observed yields of some selected boreholes (i.e the yield at completion of the borehole as determined through pumping test) and was compared with the observed yield in order to determine the efficiency of performance of the boreholes.

Table 1- Data on the Fifty (50) Boreholes Considered During the Study

S/NO	LOCATIONS AND INVENTORY NO	AQUIFER TYPE	TOTAL DEPTH (m)	DESIGNED YIELD (L/S)	STATUS AT COMPLETION	PRESENT STATUS	REMARKS
1	Shehu's Palace No. 271	L	580	15.00	Productive	Productive	-
2	Fezzan No. 273	N.A	N.A	4.00	Productive	Abandoned	Due to rupture of screens and pumping sand
3	Makera Small No.257	U	67	2.00	Productive	Productive	-
4	Hausari Big N.A	N.A	N.A	15.00	Productive	Productive	-
5	Hausari Small No.302	U	78	2.00	Productive	Productive	-
6	Hausari Kofar Lawan No. N.A	U	66	2.00	Productive	Productive	-
7	Gombole BH. C_{16} AID 205	U	100	5.00	Productive	Productive	-
8	Gombole AID 205	U	90	N.A	Productive	Abandoned	Pumping sand
9	Gombole AID 206	U	50	N.A	Productive	Abandoned	Pumping sand
10	Bulabulin No. N.A	U	66	N.A	Productive	Abandoned	Pumping sand
11	Hospital A No. 272	U	81	2.00	Productive	Productive	-
12	Race Course (No.282)	N.A	N.A	4.00	Productive	Productive	-
13	West end small No.194	U	57.4	2.00	Productive	Productive	-
14	Kasuwar Gwoza small No.349	U	100	4.00	Productive	Productive	-
15	State low cost small No.240	N.A	N.A	4.00	Productive	Abandoned	Filled with Debris
16	State low cost Big No.360	M	181	22.00	Productive	Productive	-
17	Circular Rd. 1	U	100	4.00	Productive	Productive	-
18	Circular Rd. 2	U	100	2.50	Productive	Productive	-
19	Circular Rd. 3	U	100	1.00	Productive	Productive	-
20	Play ground Sir kashim Rd. P243	U	N.A	N.A	Productive	Abandoned	Needs pump
21	Near Molai Road No.252A	U	N.A	N.A	Productive	Abandoned	Due to poor yield
22	Gwange ward Near Intersection Ahmadu Bello way and Bama Road No.263	U	97.0	0.17	Abandoned	Abandoned	Due to technical reasons
23	NA Garden No.219	U	72.2	6.30	Productive	Abandoned	Due to technical reasons
24	Zoo Area No. 218A	M	248.8	Low	Productive	Abandoned	Due to technical reasons
25	Adam Kolo new No. N.A	N.A	N.A	2.00	Productive	Productive	-
26	Shehuri North No. 732	U	68.5	4.00	Productive	Productive	-
27	Prison yard No. N.A	U	91	6.00	Productive	Productive	-
28	Maiduguri No. N.A	L	617	6.00	Productive	Productive	-
29	Shehuri South Ward No.286	U	79.2	3.75	Productive	Abandoned	Due to collapsed of casing
30	Abbatoir No.2128	U	N.A	N.A	Abandoned	Abandoned	Due to poor yield
31	Near G.R.A on Bama Rd. No. 276	M	N.A	N.A	Abandoned	Abandoned	No suitable Aquifer encountered
32	New Leather Factory No. 296	U	54.8	N.A	Abandoned	Abandoned	No suitable Aquifer encountered

Table 1- Data on the Fifty (50) Boreholes Considered During the Study (cont.)

33	Faria No.361	L	N.A	N.A	Productive	Abandoned	Needs pump and accessories
34	Ngamram old No. 275	L	575	6.00	Productive	Abandoned	Needs pump
35	State Mechanical Workshop No. N.A	N.A	N.A	19.00	Productive	Abandoned	Pumping sand
36	NEPA Gate No. N.A	N.A	N.A	2.00	Productive	Productive	-
37	Bolori No. N.A	N.A	N.A	15.00	Productive	Productive	-
38	Umar Mai saje No. N.A	U	63.1	2.00	Productive	Productive	-
39	Yerwa Small No. N.A	U	80.2	8.00	Productive	Productive	-
40	Water Works-B(BH-1)	U	58.1	2.00	Productive	Productive	-
41	Water Works-B(BH-2)	N.A	N.A	8.00	Productive	Abandoned	Filled with debris up to 15m b. g. l
42	Water Works-B(BH-3)	U	66	10.00	Productive	Productive	-
43	Water Works-B(BH-4)	U	80	10.00	Productive	Productive	-
44	Water Works-B(BH-5)	U	57	10.00	Productive	Productive	-
45	Water Works-B(BH-6)	M	160	15.00	Productive	Productive	-
46	Water Works-B(BH-7)	U	72	8.00	Productive	Productive	-
47	Water Works-B(BH-8)	U	93	6.00	Productive	Productive	-
48	Water Works-B(BH-10)	U	67.3	2.00	Productive	Productive	-
49	Maiduguri University No.307	L	627.0	8.80	Productive	Productive	-
50	Govt House No.274	M	283	18.00	Productive	Productive	-

KEY – U = Upper, M = Middle, L = Lower, N.A = Not Available

Table 2 - Comparison of Designed and Observed Yields from the Selected 50 Boreholes Studied
(KEY – U = Upper, M = Middle, L = Lower, N.A = Not Available)

S/N	LOCATIONS AND INVENTORY NO	DESIGNED BOREHOLE YIELD (L/S)	OBSERVED BOREHOLE YIELD (L/S)	DATE OF OBSERVATION	AQUIFER TYPE	EFFICIENCY OF PERFORMANCE (%)
1	Prison Yard No. N.A	6.00	6.00	19/12/11	U	100
2	State Low Cost Big No.360	22.0	15.00	1/2/11	M	68.2
3	Shehu's Palace No.271	15.00	8.50	24/1/11	L	56.7
4	Bolori No. N.A	15.00	15.00	26/4/11	M	100
5	Yerwa Small No. N.A	8.00	6.00	18/12/11	U	75
6	Water works-B (BH-5)	10.00	7.00	5/11/11	U	70
7	NEPA Gate No. N.A	2.00	2.00	19/11/11	U	100
8	Water works-B (BH-7)	8.00	8.00	7/11/11	U	100
9	Water works-B (BH-10)	14.00	3.00	16/3/11	U	21.4
10	Water works-B (BH-1)	4.00	3.50	27/10/11	U	87.5
11	Race Course No.28MA	7.00	4.00	6/4/11	U	57.1
12	Hospital A No.272	14.00	3.50	29/12/11	U	25
13	Makera Small No. N.A	15.17	8.50	6/12/11	U	56.0
14	Hausari Big No. N.A	15.00	8.0	11/4/11	U	53.3
15	Federal low cost (364MA)	21.00	20.00	24/8/11	L	95.2
16	A.I.D Gombole Rd No.204	12.30	6.00	21/6/11	U	48.8
17	A.I.D Gombole Rd No.208	12.50	5.00	16/5/11	U	40.0
18	Nursing Home Big No. 359MA	13.00	10.35	13/10/11	L	79.6
19	Govt Girls Sec. Sch. (No.259)	13.85	4.00	15/3/11	U	28.9
20	Gwange Kofar Lawan No.246	20.00	10.53	21/1/11	L	52.7

Table 3 shows the t-test result (paired two samples mean for designed and observed boreholes yields)

at 0.05 confidence level and the critical t-values at both one-tail and two-tail are less than the t-stat (calculated) value. This indicates that there is a significant difference between the boreholes' designed and observed yields. Also correlation between designed borehole yield and observed borehole yield showed that there is a positive linear correlation between observations, with the r value of 0.697 and R^2 value of 0.48. However, this positive linear correlation is not perfect which indicates that comparison between the yields is low. This also further confirmed the results obtained by the t-test.

Table 3 –T-Test Result (Paired Two Samples Mean for Designed and Observed Boreholes Yields)

t-Test	Designed Yield	Observed Yield
Mean	12.391	7.744
Variance	29.092	21.216
Observations	20	20
Pearson Correlation	0.697	
Hypothesized Mean Difference	0	
Df	19	
t-Stat	5.251	
P(T<=t) one-tail	2.271E-05	
t-Critical one-tail	1.729	
P(T<=t) two-tail	4.543E-05	
t-Critical two-tail	2.093	

Table 4 presents the t-test result (paired two samples mean for designed borehole yield and their efficiencies) at 0.05 confidence level and the correlation between designed boreholes yields and their efficiencies shows that there is negative linear correlation between observations, with the r value of - 0.408 and R^2 value of 0.17. However, this negative linear correlation is not perfect which indicates poor performance. Table 5 presents the t-test result (paired two samples mean for observed borehole yield and their efficiencies) at 0.05 confidence level and the correlation between observed borehole yields and their efficiencies shows that there is a positive linear correlation but not perfect, with the r value of 0.324 and R^2 value of 0.10.

Table 4 – t-Test Result (paired two samples mean for designed borehole yields and their efficiencies)

t-Test	Designed Yield	Efficiency
Mean	12.391	67.335
Variance	29.092	821.338
Observations	20	20
Pearson Correlation	-0.408	
Hypothesized Mean Difference	0	
Df	19	
t-Stat	-7.862	
P(T<=t) one-tail	1.082E-07	
t-Critical one-tail	1.729	
P(T<=t) two-tail	2.165E-07	
t-Critical two-tail	2.093	

Table 5 – t-Test Result (paired two samples mean for designed borehole yields and their efficiencies)

t-Test	Designed Yield	Efficiency
Mean	7.744	67.335
Variance	21.216	821.338
Observations	20	20
Pearson Correlation	0.323	
Hypothesized Mean Difference	0	
Df	19	
t-Stat	-9.685	
P(T<=t) one-tail	4.391E-09	
t-Critical one-tail	1.729	
P(T<=t) two-tail	8.782E-09	
t-Critical two-tail	2.093	

However, this positive linear correlation is not perfect which indicates low performance. In this case, the failures were as a result of operation, maintenance and Hydro-geological reasons. The overall results of the two approaches as regard to the study of the performances of boreholes in Maiduguri Metropolis showed that out of 36% boreholes abandoned, 16.67% were due to technical failure and also comparisons between designed boreholes yields and observed boreholes yields showed that yields were low and poor performances. This was due to operation/maintenance and hydro-geological failures.

4. CONCLUSIONS

From this study the following conclusion were drawn:

i. Result revealed that 64% of the boreholes were productive while 36% were abandoned. Among the productive ones, it was further found out that their performances were above 50% efficiency.
ii. 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).

The following suggestions were made from the study:

i. Proper geological and geophysical investigations should be carried out by the competent personnel prior to drilling in order to save cost and energy wastage as a result of abortive boreholes.
ii. Blockage as a result of deposition of silts within the borehole (siltation) can be removed by air lifting the boreholes whenever the need arises.

Various data on boreholes such as depth, yields, completion data, water quality, variations in water level, completion methods and maintenance procedures should be kept for each every boreholes-sunk within the metropolis

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