Performance of Motorized Borehole Systems for Residential Potable Water Supplies in Zaria, Nigeria

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***Abstract*—Opinions of the households using motorized borehole systems for their water needs in Zango area of Zaria in Nigeria about the systems performance were sampled. Well structured questionnaires were purposively administered on the identified households. The result discloses that water from the systems is used for nearly all domestic activities in most of the houses. Only 7% of the houses complained of hardness as a problem. 78.57% do not treat the water before use. The main conclusion is that the systems are high in reliability and capable of satisfying the households' water needs. However potential for serious contaminations exist in many of the houses due to presence of sock away pits. It is recommended that households should understand the nature of the problems with the water so as to know the right treatments before use and government should regulate the use of this system for residential water supply.**

***Index Terms*—Performance, motorized borehole system, potable water supplies, water quality.**

I. Introduction

Water is surpassed only by air out of all the natural resources on earth in order of importance. It is unique amongst all natural resources because whilst it is renewable, it is not replaceable. There are various substitutes for energy sources and most commodities, but there is no substitute for water. Once it is gone or degraded through overuse or pollution, it cannot be substituted. Clean water, free of pollution, bacteria and other contaminants, is the bedrock upon which sustainable, thriving and equitable human societies are built [1]. According to the International Institute for Environment and Development (2009) in [2], approximately 50,000 water supply points have effectively died across Africa. In a survey carried out by Water Aid, in Mali, 80% of wells were dysfunctional while in Ghana 58% of water points required repair. Studies carried out in some parts of Nigeria revealed a high failure rate of boreholes [3].

A borehole is a round hole that penetrates the earth's surface to underground stores of water held in permeable rock known as aquifers. The water is pumped to a supply point on the surface. The pumping is done either with a hand pump or motorized pump. Boreholes are used to extract water, usually from depths between 20m and 200m. Typically they are 100mm to 1000mm in diameter and water is pumped to the surface through a main 25mm to 300mm in diameter. Boreholes require constant maintenance and the demands and costs of providing such maintenance is often overlooked [2].

It has been reported by [4] that the number of people using boreholes (which are usually hand pump-operated) grew from 1 billion in 1990 to 1.3 billion in 2010. While boreholes offer significant advantages over dug wells in terms of water quality, many boreholes with hand pumps still impose a considerable burden on users in terms of the time and effort needed to collect the water [4]. Longe *et al*. (2009) in [5] revealed about a study on the state of water supply facilities in 43 communities of Ibeju-Lekki and Eti-Osa LGAs of Lagos State, Nigeria that all the boreholes fitted with hand-pumps had failed, while 86% of those fitted with electrical pumps had equally failed.

A. Measurement of Performance of Water Supply

According to [6] one of the basic steps towards the improvement of a physical system is the evaluation of the performance of such a system already in operation, and the utilization of the information so derived in the design, construction and operation of new ones. Satisfactory performance of motorized boreholes will involve less frequent failures and hence high reliability, high maintainability, the system being alive and well most of the times and quality of the product (water in this case) from the system. The most important performance indicators identified by [7] are:

1) Water quality [where the basic questions are: does it look good? does it taste good? does it smell good? and is it disinfected? / is the source protection in order?]
2) reliability [measured as working tap days as a percentage of the maximum possible]; and
3) source sustainability [where this is an indicator showing either the level in the dam, the flow in the spring or the level in the borehole, relative to some minimum allowable level].

Reference [8] enumerated five different variables to be considered in measuring the effectiveness of a water supply system as follows: frequency of breakdowns in the system, time taken to repair the breakdown, seasonal variation in water supply, users' satisfaction with water pressure and user's perception on quality of water supplied.

II. Methodology

A. Data Collection

The primary data for the study was obtained through the use of a well structured multiple choice questionnaires from which the respondents were requested to select the option(s) that apply to them. The questions asked were about the performance indicators as identified from the literature and

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these include the qualities of the households, water supply, treatment, storage and usage as well as efficiency and sustainability of the motorized borehole systems for potable water supply. Questions about the qualities of the households were also asked.

B. Sampling Technique and Sample Size

Questionnaires were purposively administered on the households identified to be using motorized borehole systems for their water needs in Zango area of Zaria in Kaduna state of Nigeria. At the time of the study, the exact number of households with motorized boreholes was not known and what was done was to reach out to as many as could be identified and were willing to participate in the study. Thirty six (36) houses were identified in the neighbourhood and twenty eight (28) of them completed and returned the questionnaires which were used for analysis. This represents a 77.78% response rate and this according to Morgan (2007) in [9] is adequate.

III. Presentation and Analysis of Data

The data generated from the study are presented in tables and figures and simple percentage analysis were performed on some while the computation of mean was done for some questions that involved the use of Likert scale. These computations were done using the weighted average formula:

$$\bar{x} = \frac{\sum fx}{\sum f}$$

where $\overline{x}$ = mean, x= points on the Likert scale (0, 1, 2, 3 and 4), f= frequency of respondents choice of each point on the Likert scale.

A. Qualities of the Households

The respondents were asked about the type of their housing unit, the number of full time residents and the various uses to which the water from the borehole is put. Their responses are as presented in Fig. 1 and Fig. 2 and Table I.

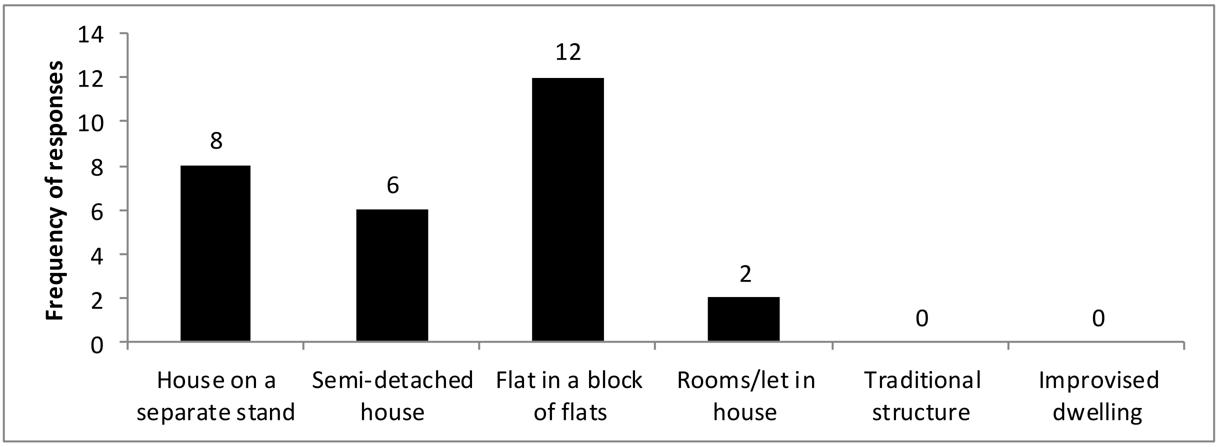

Fig. 1. Types of housing units.

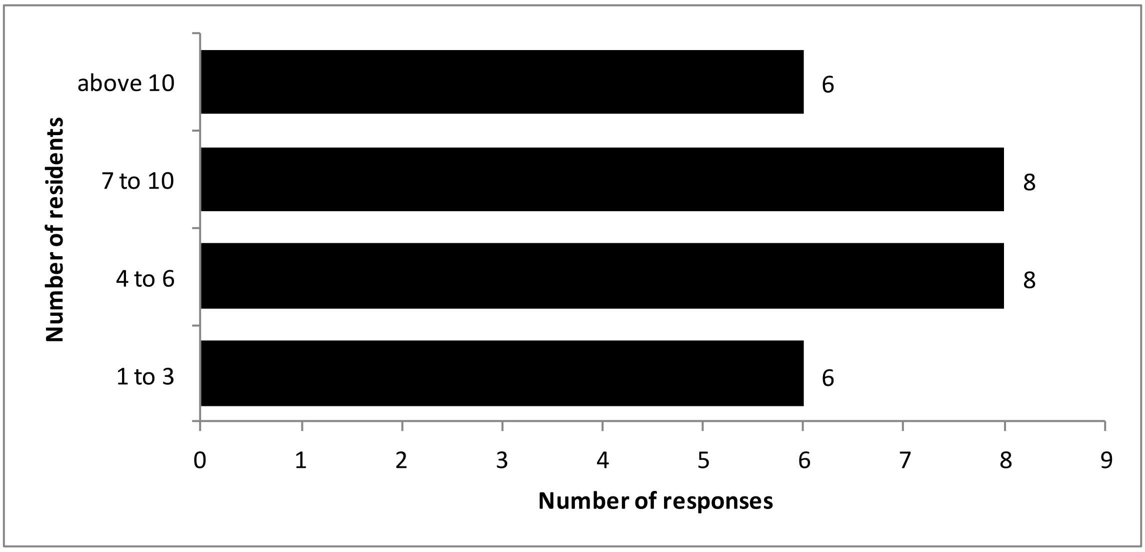

Fig. 2. Number of full time residents.

Fig. 1 showed that eight respondents representing 29% of the surveyed population live in houses on a separate property (i.e. fully detached), six (21%), twelve (43%) and two (7%) are accommodated in semi-detached houses, flat in a block of flats and single rooms/let in houses respectively.

The survey revealed in Fig. 2 that 6 (43%) of the houses surveyed have 1–3 full-time residents, 8 (57%) has 4-6 residents, another 8 (57%) has 7-10 residents while more than 10 people are accommodated in the remaining 6 (57%) houses.

TABLE I: USES OF WATER

Uses of water	Responses	Percentage (%)
Drinking	20	71
Cooking	28	100
Bathing	28	100
Dish washing	28	100
Clothes washing	28	100
Sanitation	28	100
Ablution	20	71
Watering of flowers	18	64
Drinking by animals	8	29

It can be seen from Table I that all the houses investigated use the water from the borehole in their premises for cooking, bathing, clothes and dish washing and toilet flushing. 71% each also use it for drinking and ablution while 64% and 29% use it for watering of flowers and animals respectively.

B. Water Quality Concerns

The commonest quality concerns with water are unpleasant taste, colour, odour, turbidity and hardness. Of all these quality problems, it is only difficulty in obtaining lather with soap during washing (i.e. hardness) that is a problem in only 2 (about 7%) of the houses studied. 26 (93%) of the houses indicated that they do not have any problem with the quality of the water. This is an indication of the level of satisfaction of the households with the water quality.

C. Features of the Water Supply System

Table II shows that 14% and 86% of the houses indicated that the water is pumped using electricity from public supply only and a combination of public supply and private generators respectively. None of the houses uses solar or wind energy to power the water pumps. This signified the reluctance of Nigerian households to embrace these clean energy sources that has been proved to perform satisfactorily in other places with similar climate for applications of this nature.

24 (86%) and 4 (14%) of the houses store their water in overhead and surface tanks respectively. Storing of water in underground reservoir and improvised containers are not practiced in any of the houses. This suggests that in most of these houses, the water will be delivered to the appliances at high enough pressures.

TABLE II: WATER SUPPLY FEATURES

Variables	Options	Frequency of occurrence	
		Number	Percentage
Means of pumping	Public supply	4	14
	Public supply & Generator	24	86
	Solar panel	0	0
	Wind mill	0	0
Water storage system	Overhead tank	24	86
	Surface tank	4	14
	Underground reservoir	0	0
Water treatment	Boiling	3	10.71
	Chlorination	1	3.57
	Filtration	2	7.14
	No treatment	22	78.57
Reliability of supply	Water is always available	23	82
	Water is mostly available	5	18
	Water is rarely available	0	0

Whereas 22 (78.57%) of the houses do not treat their water in any way, 3 (10.71%), 1 (3.57%) and 2 (7.14%) respectively boil, chlorinate and filter the water before use as a way of getting rid of the harmful organisms contained.

23 (82%) of the investigated houses stated that water is available for use at all times suggesting a high reliability of the motorized boreholes while 5 (18%) indicated that water is available most of the times which is also an indication of a reasonable degree of reliability. Refer to Table II.

D. Problems with the System

The computed figures for the means in Table III revealed that noise generated from water being pumped into reservoirs, non availability of water at some periods of the year as well as recurrent breakdown of some components of the system are not problems in all the houses surveyed (mean of 0.00 to 0.25). All the other items listed that are identified as problems are also considered not serious probably because they do not pose any serious threat to the water supply system (mean is between 0.50 and 1.27).

TABLE III: INCIDENCE OF THE PROBLEMS WITH THE SYSTEM

The problems	Scale				∑f	∑fx	Mean ($\bar{X}$)
	0	1	2	3			
Noise disturbance during pumping of water	28	0	0	0	28	0	0.00
Lack of water level indicator in the reservoir	10	12	0	2	24	18	0.75
Lack of water at some periods of the year	18	6	0	0	24	6	0.25
Frequent breakdown of the system	18	6	0	0	24	6	0.25
Overflowing of the reservoir	4	10	6	2	22	28	1.27
Suspended particles in the water	10	14	0	0	24	14	0.58
Lack of alternative supply in the event of a breakdown	16	0	4	4	24	20	0.83
Presence of a sock away within the premises	18	0	6	0	24	12	0.50
Lack of alternative power source for pumping	14	8	0	2	24	14	0.58
Unnecessary use of water	10	14	0	0	24	14	0.58

0 – Not a Problem 1 – Not Serious 2 – Serious 3 – Very Serious

E. System Effectiveness and Sustainability

1) System down times

The surveyed houses were asked how long it takes on average to restore faulty systems back to operation and 64% indicated that they have never had any problem with the systems since they have been using them. The 23% that indicated that they have had problems with the systems on a few occasions submitted that they were resolved within a day.

There is no well or any other water source in the vicinity of any of the houses investigated that has gone dry because of the operation of the boreholes. In view of this it can be declared that the boreholes do not pose any threat to the continued satisfactory performance of other sources of water in their vicinity at least in the short term. However there are serious sustainability concerns with regard to the presence of sock away pits within most of the premises and a large percentage of these are not situated far enough from the borehole as specified by [10]. In 78% of the houses, the sock away are less than the minimum specified distance of 15 metres and this present a potential source of contamination to the water.

The computed means for the listed system performance parameters in Table IV has suggested an expression of satisfaction with the performance of motorised borehole systems for residential potable water supply in the neighbourhood. The means ranges between 2.80 and 3.42 which correspond to the scale denoting that the performances are satisfactory.

TABLE IV: RATING OF SYSTEM PERFORMANCE PARAMETERS

Performance parameters	Scale				∑f	∑fx	Mean ($\bar{x}$)
	1	2	3	4			
Adequacy of storage capacity	0	0	18	6	24	78	3.25
Water pressure at the appliances	2	0	18	4	24	72	3.00
Availability of components and spare parts	0	8	8	4	20	56	2.80
Affordability of components and spare parts	0	8	8	6	22	64	2.91
Cost of maintenance	0	8	10	4	22	62	2.82
Overall system performance	0	0	14	10	24	82	3.42

1 - Very Unsatisfactory 2 – Unsatisfactory 3 – Satisfactory 4 - Very Satisfactory

IV. SUMMARY OF FINDINGS AND RECOMMENDATIONS

A. Summary of Findings

The water from the boreholes is used for most household activities in nearly all the surveyed houses. Power for pumping the water is mostly from the public supply and the water is stored in overhead tanks before use. Responses indicate high reliability of the systems and users' satisfaction about their performance.

B. Recommendations

It is advocated that households using this source of water supply should treat at least their drinking water by boiling, filtering or adding chlorine to inactivate the germs and where difficulty in obtaining lather with soap during washing is observed, the water for washing should be boiled to remove the hardness. The government on its part should regulate the use of motorized borehole systems for potable water supplies to residences and also promote the application of clean and environmentally friendly energy sources such as solar and wind for uses such as water pumping.

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