WHY BOREHOLE DRILLING AND CONSTRUCTION PROJECTS FAIL

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ABSTRACT

The history of rural water supply through groundwater development in Nigeria dates back to the colonial era when concrete open wells were constructed in an effort to provide safe water sources to the rural communities, under the supervision of the Public Works Department (PWD) of the Regional Governments. Since Independence, several National Rural Water Supply Programmes have been embarked upon by the Federal Government of Nigeria, all geared towards improving access to water supply. In addition, External Supporting Agencies such as the World Bank, UNICEF, UNDP, JICA, Water Aid etc have committed huge sum of money to rural water supply through the provision of drilling rigs, geophysical equipment, hand pumps and spare parts to ensure the sustainability of groundwater development projects. In spite of all efforts, water well construction is still characterized by cases of "failed hole", poor quality service, and unprofessional conduct of drillers. These constitute serious concerns to the government, donor agencies and sector stakeholders who see them as militating factors against the attainment of Millennium Development Goals in particular and water supply project objectives in general. Given the massive need for improved water supplies coupled with limited investment, there is an urgent need to fully understand the extent and impacts of these concerns, and develop mechanisms and strategies to improve construction quality and functionality of borehole projects in Nigeria. In order to achieve this, government is taking steps to regularize the drilling sector by developing a code of practice for water well construction, issuing procurement guidelines, promoting capacity building in the drilling sector, and encouraging the formation of drillers' association.

1.0 INTRODUCTION

According to the most recent Joint Monitoring Programme (JMP 2012) statistics, 2.3 billion people (one third of the global population) obtain their drinking water directly from groundwater and it is reasonable to assume that at least another 1.7 billion people (one quarter of the world's population) representing 40% of those who enjoy piped water are also supplied from groundwater. Of the 780 million not yet served, the majority of these predominantly rural people will need to be supplied from groundwater (Carter, 2012).

From the above statement it can be deduced that humanity relies heavily on sustainable groundwater development. Groundwater sources are found in most places and are relatively easy and cheap to install. They are also not prone to pollution as other sources of water. To bridge the gap in water supply coverage, it is crucial that boreholes are delivered in a cost effective manner. Cost effectiveness does not necessarily mean cheaper boreholes but rather that optimum value is derived over the long term for money invested. This should result in borehole continuing to function through their designed lifespan of 20 to 50 years

Studies carried out in some parts of the country revealed a high failure rate of boreholes (Eduvie and Olabode 2012).This can be attributed in part to poor borehole construction practices. One way of tackling this problem is to improve the quality and professionalism of water well drilling

2.0 HISTORY OF GROUNDWATER DEVELOPMENT IN NIGERIA

Adekile and Olabode (2009) provides a history of groundwater development in Nigeria and this is summarized in this section as follows: Prior to colonization and up to independence most of the groundwater abstraction was from unlined hand dug wells. Between 1930 and 1933 the Geological Survey of Nigeria experimented and perfected the 1.2 m diameter lined dug well. In 1947, the Public Works Department took over the construction of rural water supplies. A cable tool rig was purchased and the first rural boreholes were constructed. Rotary water drilling was introduced into the country by Balakhany Chad , a British company in 1951 mainly for drilling in township. The first major water supply drilling programme was between 1956 and 1962 when 280 boreholes were drilled in the north eastern part of the country to explore the artesian

aquifers of the Chad basin. The drilling was carried out by government drillers and Balakhany Chad.

Between independence and the beginning of the Water and Sanitation Decade in 1980, several other operators came into the country from Italy, Germany, Britain and Greece. In the mid 1980s when the Nigerian economy went into recession, some of the expatriates company closed down and left their equipment on lease to their local employees. Some of the employees who were laid off also set up their own drilling companies.

Several water supply interventions involving borehole drilling have been embarked upon by the Federal Government or its agencies. Some of these are

- National Borehole Programme (1981-1985)
- Department of Food, Roads and Rural Infrastructure (DFRRI) (1986-1992)
- Petroleum Trust Fund(PTF)Water Supply Project (1996-1999)
- Improved National Access to Water Supply and Sanitation (2000-2001)
- The Presidential Water Initiative (2003-2009)
- Millennium Development Goals Water and Sanitation Projects (On going)

Apart from the interventions listed above, there are others sponsored by external agencies. Also the various State and Local Government have been carrying out borehole programs

Water well drilling activities is presently carried out in Nigeria by both public and private sectors. Presently almost all the drilling in the country is being contracted out to the private sector. Drilling contractors operating in the country can be classified into three categories:

- Organised drilling contractors with equipment and a management structure
- Artisan drillers engaged in manual drilling or using locally fabricated rigs
- Contractors with some interest in drilling but no equipment whatsoever

The equipment used by the organised drilling sector is of several makes and comes from all over the world (eg China,_ England,_ Germany,_ Japan,_ India,_ South Africa,_ USA, and Thailand).In the early days of drilling, expatriate companies brought big, multipurpose truck

mounted rigs into the country. This was however short lived because of market forces as well as huge capital cost involved in the importation of such rigs into the country. Presently, most drilling companies in Nigeria have to make do with fairly used rigs which are imported from different parts of the world (e.g. China, England, Germany, Japan, India, South Africa, U.S.A. etc). With such a diversity of origin of equipment, it is difficult for the local suppliers to stock spare parts to meet the different brands. Even with that only few drilling companies can afford the procurement of such rigs. This problem has greatly reduced the number of rigs found in the country up to the early 2000s. Drilling organizations in Nigeria are confronted with many problems such as lack of spare parts/poor quality of materials used for borehole construction, adulterated drilling chemicals, poor procurement methods, high turnover of personnel, lack of credit facilities, third party involvement in drilling contract, long distance between contract locations.

Manual drilling is now common in Nigeria and is well patronized. Hand drilling was introduced into the northern parts of the country in the early 80,s through the Fadama studies carried out by the World Bank to evaluate the irrigation potential of the alluvial aquifers of the floodplains of major rivers in the Northern parts of Nigeria. This technique which is otherwise known as hand turning has now been massively adopted as a method of exploiting groundwater for domestic needs in most of the states of Nigeria where the method is feasible. The hand drillers are presently being patronized by house holders and owners of small scale industries. Some are well educated and display some level of entrepreneurial skills.

uPVC casing and screen are manufactured locally. Steel casings and screens and drilling chemicals are imported and stocked by local dealers. Light and medium duty rigs using reconditioned engines are fabricated locally in Kano, Lagos, Kaduna, Ibadan and in some other places in the country.

3.0 CAUSES OF BOREHOLE FAILURES

Borehole failure is defined as a situation when a borehole which was recorded as successful, or productive immediately after drilling, subsequently fails to deliver a sufficient yield of safe

water throughout the year. It is also important to note that a water supply borehole may also be deemed to have failed if the water provided by it is unsafe for human consumption.

Borehole failures can results from many causes. These causes can be classified into the following categories:

- Failures due to lack of expertise or inexperience and poor performance of the driller
- Failures caused by poor supervision
- Failures due to particular characteristics of the aquifer
- Failures caused by well users
- Failures due to poor technological choice

3.1 FAILURES DUE TOLACK OF EXPERTISE AND POOR PERFORMANCE OF THE DRILLER

For a borehole to serve its intended purpose it is expected that drilling and construction activities are carried out according to established standards and code. One reason for high failure rate experienced in the drilling sector in Nigeria is lack of professionalism exhibited by some of the drillers. Quacks have infiltrated the drilling sector and their activities have led to the failures of many boreholes. Some of the bad or unprofessional practices of such drillers are as follows:

- Drilling of crooked boreholes which affect installation of casing ,screens and pumps
- Poor collection of samples, and essential data like penetration rate log, lithological log, etc during drilling operation. This can lead to poor design and subsequently well failure
- Use of drilling fluid in such proportion that will lead to sealing of the intake portion of the well with mud cake or cause excessive mud invasion into the aquifer system
- Use of substandard casings and screens in an attempt to save cost. This can result into causing an incursion of soil or formational materials into the well
- Use of inappropriate gravel packs materials like rock chippings
- Lack of placement of sanitary seal or grout.

- Inadequate well development as a result of which natural silts and clays, drill cuttings or other foreign matters which could render the well useless of its intended use are not removed
- Improper conducts of pumping test, in some cases pumping test data are forged as a result of which inappropriate pump is selected. Such pump may get burnt after some time especially if it is oversize

The Nigeria Code of Practice for Water Well Construction clearly spells out best practices for drilling sustainable boreholes.

3.2 FAILURES DUE TO POOR SUPERVISION OF BOREHOLE DRILLING AND CONSTRUCTION

Good supervision of water well drilling is essential for the provision of sustainable water wells. The aim of supervising borehole drilling is to ensure that boreholes are produced as designed and all data collected during drilling are accurately recorded and reported to the relevant agencies. Without good supervision the quality of the work may be compromised. (Adekile 2012)

A supervisor is expected to display great professionalism in carrying out his/her duties. A good knowledge of geology, hydrogeology and borehole construction is important. Capacity for proper supervision in terms of experienced personnel and equipment is limited at local government and state level. Although the federal government and external support agencies do engage consultants to carry out supervision, unfortunately some of these consultants lack the vital equipments such as borehole camera, dip meter etc required for effective supervision. The consequences of no supervision or inadequate supervision are that some drillers cut corners, save themselves money and not only let down the client but more importantly those who need the water. In some cases where consultants or agency staffs are engaged for field supervision of drilling, they are poorly compensated and rely on drillers for logistical support. This in turn means that the supervisor may come under the undue influence of the contractor.

3.3 FAILURES DUE TO CHARACTERISTICS OF THE FORMATION

Borehole failure can also result from formational problem. The nature and composition of a formation can lead to problems like aggressive groundwater, groundwater mining and difficulty in drilling all of which can eventually leads to borehole failure.

For example the groundwater in the deep aquifer (200-300mm deep) of Lagos is aggressive and the steel lining tends to corrode after some years. The boreholes tend to have a short lifespan and have to be replaced after 10 years. Attempt to overcome this by coating the casings in bitumen did not work as the corrosion seems to start between the joints in the casing and the screen. At a stage, Lagos State Water Corporation experimented with fiber glass lining but this also failed for unknown reasons .Nigeria Breweries tried stainless steel casing and screen but the corrosion problem did not stop. Eventually they opted for 32 bar Boode uPVC casing and screen manufactured in Germany.

Also, there are some difficult groundwater formations in Nigeria. Such formations are difficult to drill and in most cases borehole easily failed in such area. Eduvie (2008) gave a list of such areas as stated below

Sedimentary Areas

- Otukpo, Benue State (due to deep static water level)
- Alloma, Otukpa Kogi State (due to deep static water level)
- Enugu Enugu State SE (due to deep static water level)
- Nsukka Enugu State (due to deep static water level)
- Omule Abia State (due to deep static water level)
- Brass Rivers State (due to saline groundwater and poor access)
- Okpoma Cross River Sate (due to saline groundwater and poor access)
- Odikpani, Cross Rivers State (due to deep static water level)
- Yenegua Balyesa State (due to saline groundwater and Iron)
- Ekpoma, Edo State (due to deep static water level)
- Epe Lagos State (due to saline ground water)

- Basement Areas
    - Rubu, Faskari Katsina State (due to lack of fractures/weathered basement)
    - Anka, Tsafe, Gusua, Maru, etc Zamfara State (due to lack of fractures)

3.4 FAILURES CAUSED BY WELL USERS

Cases of groundwater mining caused by over abstraction have been reported in Lagos and Maiduguri. Table 1 below shows the different rates of decline measured by several workers in the Lagos area. In Maiduguri several of the artesian boreholes in the Chad Formation aquifers have lost their head and are no longer free flowing. More exploitation will lead to further decline of water level. Over pumping is the most common well problem that leads to premature well failure. It not only depletes the aquifer, but it rapidly increases the rate of corrosion in borehole lined with metallic casings .It also increases the rate of sediment particulates moving towards the well. It can also cause the aquifer to settle and compact which further restricts water flow to the well

TABLE 1 GROUNDWATER LOWERING IN SOME PART OF LAGOS

SOURCE	**ESTIMATED LOWERING OF GROUND WATER LEVEL**
Kampsax-Kruger	Between 1970 and 1975=1-1.5m in Ilupeju and Ikeja predominantly from industrial abstraction. Over 230 boreholes in operation
Onwuka and Adekile	By 1986 annual decline of 2.2,2.0 and 1.6 m in Ikeja, Agege and Iganmu
Scanwater	By 1978 reported annual decline of 2m since 1967 in Agege
Blizzard et al	By 1996 GWL stabilization in Ikeja and Isolo with less than 25% public water supply boreholes functioning and most factories operating at less than 50% capacity.

Source Adekile and Olabode 2009

3.5 FAILURES DUE TO POOR TECHNOLOGICAL CHOICE

Technology should not be predetermined in any rural water supply programme, rather the final choice of technology should be made by the community from a range of feasible options. Communities need to be encouraged to select feasible options rather than fashionable options. They must be given real freedom to select their own technology however low cost and not pushed towards the implementer's preferred choices. Many projects have failed because the users are not carried along in the technological choice. In some cases fashionable choice were made for some communities that lack the potential of maintaining such technological option

chosen for them. These have resulted in the breakdown of many boreholes. Olabode and Rimfat (2001) shows that in parts of Jigawa, Yobe and Kano states the water facilities designed by government and constructed with little or no community involvement are not adequately maintained and some have been abandoned. The study shows that whilst most of the hand pumps are in good working condition because the technology is so simple that the village mechanic and bicycle repairer can repair the pumps, about 58% of the motorized schemes have ceased functioning. Most of the problems had to do with inability to carry out repairs on the attached generators or lack of money to buy diesel and lubricants necessary to run the generator. If the communities are properly guided to make feasible choice of technology in water supply projects, the menace of broken down boreholes will be reduced.

3.6 OTHER FACTORS THAT CAN LEAD TO FAILURE

Other factors that can directly or indirectly lead to failure of borehole projects are:

- Unrealistic costing and pricing. At times pressures are put on companies to undertake works at unrealistically low prices with promises of future and better contracts
- Unfair contract terms and conditions
- Third party contract- subcontracting by brief case companies to professional companies as a result of which profit on the project is shared among two companies
- Abuse of tender process as a result of which contract is awarded to a company based on connection and not on capability

All these can make the contractor compromise the quality of the work and this eventually will lead to failure of the project with time.

4.0 GOVERNMENT EFFORTS IN ADDRESSING IDENTIFIED CAUSES OF BOREHOLE FAILURES

The high rate of borehole failure in the country has caused government to act in regulating the drilling industry by taking the following steps:

4.1 Publication of the Code of Practice in Water Well Construction

The National Water Resources Institute in partnership with the Standards Organization of Nigeria, representatives of the Federal Ministry of Agriculture and Water Resources, Nigerian Society of Engineers, Council of Mining Engineers and Geo-Scientists, Nigerian Association of Hydrogeologists, State Rural Water Supply and Sanitation Agencies, Private borehole drilling companies and Nigerian Universities developed a code of practice for water well construction to provide the framework for water well construction in Nigeria.

The Code of Practice for Water Well Construction is a documentation of standard procedures, mandatory quality control and specification requirements for drilling of water wells in Nigeria.

Consistent with the duty of safeguarding public investment, welfare, safety, health and to protect, develop and manage groundwater resources of the Nation, the code sets the :

- Minimum standards for drillers, supervising personnel and equipment to ensure cost effective water well construction and sustainable groundwater resources development in Nigeria.
- Standard rules governing the location, construction, maintenance and abandonment of water well, and the installation of pumps and pumping equipment.
- Standard rules to conserve and protect the groundwater resources of the Nation against contamination.
- Standard rules that ensures safety on all water well drilling activities.
  In order to create awareness on the existence of the code, sensitization workshops were organized in all the six geopolitical zones of the country.

4.2 Issuance of procurement guidelines

One of the strategies employed by the government in bringing sanity into procurement of public works in Nigeria is the enactment of the Public Procurement Act. This act applies also to borehole projects.

Procurement of boreholes usually involves the appointment of consultants for the sitting, design and supervision of boreholes; contractors for the drilling of the boreholes; and suppliers for the supply of drilling equipment, pumps, tanks, pipes and spare parts. Public procurement is undertaken with consideration of economic benefits to the public within national goals. Nigeria enacted the Public Procurement Regulation for Goods and Works in year 2007. The regulations apply to all procuring entities and participants in public contracts and to all public procurements of goods and works except where a waiver has been obtained. The Procurement act provides for grouping of contracts to obtain economies of scales and reduce procurement cost. Besides national procurement acts, there are other governing provisions such as national water policies, strategic frame works on rural water supply and technical guidelines.

4.3 Capacity Building

The Federal Government of Nigeria set up the National Water Resources Institute in 1977. The Institute is responsible for conducting training courses for all cadres of man power development for the water industry. Apart from regular programmes of the Institute the Institute conducts courses in groundwater related areas such as:

- Borehole sitting
- Borehole drilling technology
- Borehole construction and management
- Borehole Rehabilitation and development
- Handpump installation and maintenance

The Institute also runs outreach training courses which provide on the job training for staff of particular agencies at their location. The National Water Resources Institute is also carrying out a project on Standardization of Water Well Drilling Rig Fabrication including Development of Rig Fabrication Models. The project which is in line with the Reformation and vision 20/20 of the Federal Government, principally aimed at

I. Standardizing the design and processes for local water well drilling rigs fabrication

II. Building indigenous capacities on fabrications of water well drilling rigs
III. Ensure availability of standardized spare parts for local fabrication of water well drilling rigs

All these efforts of the government are in realization of tackling the enormous challenges of groundwater development.

5.0 CONCLUSION

Nigeria has experienced over 60 years of water well drilling with the private sector taken over the drilling of boreholes in the country. In all the states there are committed drillers who have invested personal savings in the industry. Such dynamism in the industry is however not without challenges. There is much that needs to be done to further improve drilling situation in the country. The following recommendations will go a long way to achieve this.

1. Government at all levels should ensure that competent professionals are selected to carry out drilling works
2. Government should intensify effort to commence licensing of drillers as enshrined in the code of practice for water well drilling. This will go a long way to check the activities of quacks.
3. Government need to continue to strengthen procurement process and develop the capacity of institutions and individuals involved in procurement and encourage work ethics that promote public good over individual interest
4. Federal Government should provide support to the drillers association as a forum for discussion with the drillers, professionalizing borehole drilling and increasing the capacity of drillers for cost effective drilling
5. State Government should identify the manpower and capacity development requirements of their staff for effective supervision of borehole drilling and provide the training ,tools and enabling environment required by such staff for effective supervision of borehole contracts

6. Local Government Authorities should keep inventories of boreholes within their areas and monitor their functionality and support the communities in the maintenance of the facilities
7. Sustainable groundwater supplies in the future depend on the data and information of the past and present. Drilling organizations as well as government agencies involved in groundwater development should collect and keep data.

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