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The Role of Manual Drilling Methods in the Provision of Potable Water

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Abstract: *The paper presents some manual drilling methods that are common in our society, especially the rural areas. The advantages of each method and their respective limitations have been highlighted. The effects of drilling additives on water quality and the health impact on consumers. The review also proposes a simple bacteriological test and analysis of the water sample from a given borehole that should be carried out after drilling and before consumption.*

Keywords: *drilling additives, analysis of water sample, potability of the water sample*

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1.0 Introduction

Water is the most demanding and most competing resource in the world (Eddy and Garg, 2021). Although different sources of water are available, the progressive introduction of contaminants to the different water bodies is a current and major challenge that must be arrested (Eddy *et al*., when 2004, 2006). Among the different water bodies, underground water is the least affected most contaminants are introduced to a given environment. However, the quality of underground water depends on the depth (Huang *et al*., 2019). Water that occupies the voids and pore spaces underneath the earth's crust is called groundwater. Groundwater is one of the earth's most widely distributed resources and is increasingly catering to the requirements of the domestic, industrial and agricultural sectors. The value of groundwater is because it is dependable, widely distributed and can be put to use with ease and speed. Besides, the groundwater schemes have a very short gestation period and the resources are directly under the control of the uses. In recent years, rapid progress has been made in the development of groundwater resources, especially for irrigation and domestic use (Adagunodo *et al* ., 2018' Akujieze and Oteze, 2003; Sunkari *et al*., 2021)

In general, the term groundwater or surface water refers to the water that occurs below the surface of the earth. The main source of groundwater is infiltration. The infiltrated water after meeting the soil moisture deficiency percolates deeply and becomes groundwater. The groundwater is free from pollution and is useful for domestic use in small towns and isolated farms. It can be made available at a small capital cost and also at the least possible time to avoid regions. Groundwater is often the only reliable source of water for irrigation. Groundwater has been an important water source for all ages. Like any other natural resource, groundwater is also unlimited. They must be wisely managed and protected against undue exploitation and contamination by pollutants or saltwater.

2.0 Borehole and Drilling Methods

When a hole is drilled underneath the earth's surface to access groundwater, it is called a borehole. There are many techniques used to sink wells more easily, more rapidly and to a greater depth than hand-dug or driven wells. A bored well is a cylindrical hoe sunk vertically by percussion or the rotary action of a cutting tool turning around a vertical axis. The diameter of a bored well can vary from 5cm and 1.5 m. nearly all these wells are normally fitted with a water pump. The pump (manual, motor-driven, submersible) is chosen according to the good depth, the desired operating flow rate and the resources (technical, financial and logistical) that are potentially available. A borehole is an ancient technique dating back over three thousand years. It originated in China where bits of bamboo attached to a heavy weight were used to drill water wells. There are two main approaches to borehole drilling (Chinyem, 2017) (i) Manual drilling using tools for fairly shallow wells up to 40 m deep. (ii) Mechanical drilling using light equipment or a drilling platform and heavy equipment which can reach greater depths. In some cases, the mechanized drilling machines are fitted on self-propelled mobile platforms that are much quicker and easier to use and which can drill into the hard ground at great depth. They are however far more cumbersome, expensive and unavoidable by the rural residents. Therefore, manual drilling can not be completely avoided.

Manual drilling is a practical solution that (although it uses human energy), tiring, is advantageous and inexpensive for water points less than 40 meters deep in soft ground such as clay or sand and soft rock like soft sandstone(Martínez-Santos *et al*., 2020). Under a suitable geological environment, a manual borehole can prove to be more than four times cheaper than a mechanized borehole. But in hard ground, or when wishing to drill to a great depth or avoid difficult work or go faster and the mean is available, mechanized boreholes and a better, even essential solution (Capstick *et al*., 2017) The provision of manual boreholes is of interest to the NGOs and public authorities because these techniques can produce more wells. They also appeal to villages, small communities and farmers in rural areas with few resources as they can drill small boreholes themselves with a minimum financial involvement (Liddle *et al*., 2015). Given their necessity and wider application, this review seeks to describe and classify the main processes by distinguishing between the manual boreholes and the mechanized boreholes.

2.1 Manual boreholes

They are primarily preferred because of the low cost involves in prospecting for water in relatively shallow depths and suitable environments. Some of the techniques associated with manual drilling are highlighted in the table below. Table 1 presents information on some possible depths of penetration by different manual methods in various environments.

2.1.1 Hand-auger drilling

Hand-auger drilling involves turning a gimlet, or auger, with a large handle. Steel extensions are added as the auger is forced into the ground. When the auger is filled with spoil, it is hauled up to be emptied and then the operation is repeated. The borehole normally remains open above the level of the water table and does not require shorting up and a temporary preliminary well casing can be used when the water table is reached to prevent the borehole walls from collapsing. Drilling continues inside this preliminary well casing with a bailer until the desired depth is reached. The temporary well casing is then removed and the permanent casing is installed.

Fig. 1: Set up for Auger drilling method

Auger-auger drilling can be up to 15 to 25 metres deep depending on the geological formation (Table 1).

Percussion drilling is a method that can be used to replace the auger or wash boring methods especially when the drilling environment is a very stiff soil or rock (Patel, 2019). The method can be used in various soils types except for granite basement rock (Table 1). In percussion drilling, depth penetration is achieved by alternatively lifting and dropping a heavy cutting or hammering bit that is suspended by a rope or cable. This mass is often lowered into an open hole or inside a temporary casing. In most cases, a tripod is used to support the cable (Fig. 2). The percussion (or stone hammer) technique is normally used for depths up to 25 meters for drinking water, but deeper boreholes can be achieved with this method. The method can be combined with other techniques like hand-auger drilling, which drills the first few metres of the borehole quickly as far as hard ground jetting or wash bore drilling.

Table 1: Efficiency of some manual drilling methods in various geological environments

Drilling techniques	Mean drilling speed for various geological formations (per 15 m)				
	Weak and cohesive sand, silt and gravel	**Soft clay stiff clay formation**	**Soft consolidated formation**	**Soft weathered rock**	**Crystalline basement rock**
Hand auger	1	2-4	Not applicable	Not applicable	Not applicable
Rota sludging	1-2	2-3	>3	Low effciency	Not applicable
Percussion	2-3	3-4	>3	>8	Not applicable
Rotary jetting	1	1-2	Not applicable	Not applicable	Not applicable

3.1.4 Mobile drilling platform

Drilling platform on a trick: This rotary drilling technique uses heavy piercing machinery which can reach great depths. The machinery is mounted on large straight or tracked vehicles. It uses rotary drill equipment that pierces, chews up, or breaks the rocks off. The ground is soft, large gimlets called augurs. The borehole can be several hundred meters deep. A pump is often installed at the bottom of the borehole to pump the water up to the surface.

3.1.6 Benefits of boreholes

Some of the benefits of boreholes are

- (i) Provision of water for domestic, agriculture and industrial purposes
- (ii) Provision of income through direct or indirect sales
- (iii) Utilization of natural resources
- (iv) Saving of cost

3.2 Component of drilling fluid

The drilling fluid is the most abundant waste material produced after the completion of any drilling exercise. Borehole stability remains the main problem during drilling and the selection of drilling fluid type and composition are the origin of successful drilling. They are generally required to comply with three important requirements: (a) they must be easy to use; (b) not too expensive and (c) environmentally friendly.

Drilling fluids are used basically to provide hydrostatic pressure to prevent geological formation fluids from entering into the wellbore,, cooling and lubricating the drill bit and rods. Their other functions include the extrusion of drill cuttings and suspension of drill cuttings when there is a purse in drilling and when the drilling assembly is brought in or out of the hole to drop them in surface disposal areas. The additional functions of drilling fluid include:

(i) Improving sample revering
(ii) Controlling formation pressures
(iii) Protecting the soil strata of interest
(iv) Minimizing drilling fluid losses into the formation
(v) Facilitating the free movement of the drill string and casing
(vi) Reducing wear and corrosion of the drilling equipment.
(vii) Drilling mud may consist of bentonite clay, with additives such as barium sulphate or the hematite, partially hydrolyzed polyacrglamide (PHPA), drilling detergents.

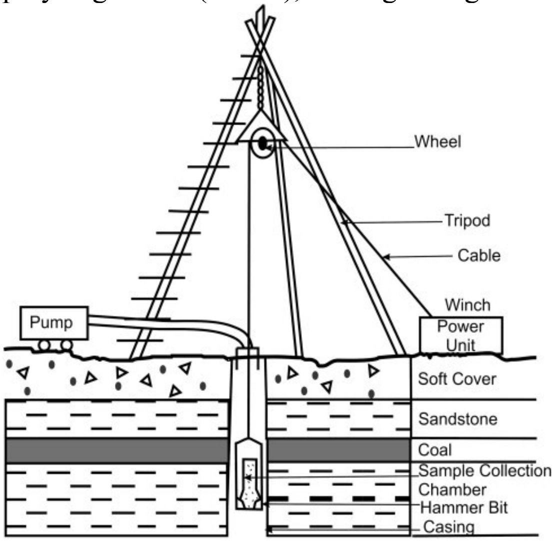

Table 2: Diagram for the percussion drilling

4.0 Environmental Impact of Drilling

An investigation was carried out to determine the effect of each of three different drilling fluids on groundwater samples, three monitoring wells were installed in boring that was constructed using water-based drilling fluids containing guar beam, guar beam with breakdown additives and bentonites. Their effects on the chemistry of water samples were subsequently analysed using samples from the well. It was observed that the bentonite and guar drilling fluid temporarily caused deviations in the chemical oxygen demand (COD) of groundwater samples collected from the monitoring wells. The elevated COD levels were attributed to the large concentrations of oxidizable carbon present in the guar beam drilling fluid and the organic polymers present in the bentonite drilling fluid.

4.1 Disposal impact

Drilling mud chemistry is quite complicated and the consequence of discharging mud into the environment is still not completely understood, despite growing related research. Water well drilling activities produce wastes that need to be disposed of in a manner that is both economical and safe for the environment. Water-based mud (WBM) is disposed of when the drilling job is completed. In many cases, some treatment should be given to the mud before being discharged or disposed of such treatment include subjecting the mud to a series of chemical alteration in the mud characteristics before they are disposed of.

4.2 Impact on the soil geology

Disposal of drilling mud and drilling debris, into the land near project areas tends to alter soil texture, structure and even constituents of the soil. This may be very injurious to agricultural practice and also damage to our natural environment may be very disastrous to our environment in the long term and distant future. A proper disposal technique should be sought with maximum protection to our environment and groundwater source. The best form of disposal remains underground injection control (UIC).

4.3 Impact on groundwater resources

The boreholes provide a direct connection to aquifers. That is groundwater storage reservoir and formation. Therefore, boreholes must be adequately protected from all forms of contaminants that may endanger our groundwater sources. Introduction of pollutants through well into groundwater systems may not only present us with the challenge of unsafe drinking water or potable water also increase the cost of the borehole water source as a sample water treatment will become inevitable for the safety of consumers.

4.4 Impact on wildlife

All drilling and production activity has an immediate impact on the wildlife and behaviour patterns of local species. Temporal disruption in irrigation pathways, change in food availability, noise and potential spill and chemical contamination are serious threats that need to be avoided.

4.5 Economic impact

The economic status of the community with a potable water supply is bound to accelerate as a result of a constant water supply. Small scale (subsistent) farming will be motivated and encouraged and commercial farming within the area will be highly successful. People will likely choose livestock keeping especially CONS, goats, poultry farming as their economic mainstay. The supply of water will not only be beneficial to the animal but also water the land for greener pastures. The waste generated from animal farming will be sued to improve soil fertility to increase farm produce.

5.0 Management protocols

5.1 Enhanced health standard

The provision of clean, adequate and potable water from the borehole will promote positively general health and hygiene of the whole local population. This is because diseases associated with the water of low quality will be controlled (WHO, 2008)

5.2 Reduce water-borne diseases

It is a requirement that no well or borehole water should be used before a physical, chemical and bacteriological analysis of the water sample has been carried out. Since water sample analysis proceeds consumption of the water, the tendency is that it will reduce and can end the prevalence and occurrence of water-borne diseases like typhoid (Ukere, 2010; Eddy and Ekop, 2007)).

5.3 Promotion of development

The provision of water through the drilling of the borehole will eliminate people to come and invest in the area by opening shops, schools, hostels, etc. any business activity of interest will be facilitated with the provision of water within the area (Thalter, 2000' Thomas, 2000). Water-based industries will be established as proximity to what will certainly be a factor for consideration.

6.0 Summary, conclusion and recommendation

Groundwater generally does not get polluted, if it is away (at least 20 m) from the sanitary works. The water gets filtered while percolating through sand and stones. Therefore, groundwater remains pure and clean.

- Since the bored well is closed, there is no risk of getting contaminated.
- Since it is closed, no danger of children or animals falling into it.
- The temperature of deep water remains stable. It feels cool in summer and warm in winter
- Since bore wells are deep, the chances of water remaining available in summer are more.

When we drill a borehole to tap into groundwater resources, we give a lot of consideration to the likely availability of groundwater and the likely chemical characteristics of the water via our boreholes' prognosis. However, we also give a lot of consideration to how to properly construct the borehole and the associated infrastructure and the likely effect that that work will have on the groundwater. When drilling a borehole we recognize that the drilling works themselves will have an impact on the groundwater.

Initially, as drilling progresses towards the groundwater table, the groundwater will be suppressed as a result of the downward pressure being exerted by the drilling. Once a water strike has occurred and the water table has been intercepted, we have exposed controlled water and it is therefore important that all works from this point forward protect the water both for the sake of the proposed use, such as drinking water, but also to protect the environment. Any additives used need to be suitable and not potentially damaging.

Sealants and materials used to construct the borehole have to be used appropriately to ensure that they do not contaminate the groundwater.

Post-construction the borehole needs to have constructed such that no contamination can migrate down to the water table as the borehole forms a direct pathway to the groundwater.

In view of the findings deduced from this review, the following recommendations are proposed,

((i) Water borehole drilling is an investment that must yield adequate returns to justify such development. Thus pre-drilling exercises such as geophysical exploration should be carried out before final decision making about sinking a well in any geological formation. This will surely not only enhance sustainability and availability of the water resources within the drilling formation but also prevent the failure of such an enormous environment.

(ii) As a result of the negative impact from drilling wells emanating from drilling fluids and additives added to drilling mud to enhance the drilling process, some wastes are being generated along the process. These wastes constitute contaminants to groundwater and directly affect the quality of groundwater. They should be carefully disposed of with maximum protection to groundwater sources. The objective is to cause physical and chemical alteration to the waste characteristics before being disposed of.

(iii) In situations where prior treatment has been not given to wastes, the safest method to dispose of such wastes is through injection wells. A class one injection well may be used for the disposal of toxic wastes emanating from drilling with protection to groundwater resources.

(iv) For the health of the beneficiaries, it calls for a simple bacteriological analysis of the water sample from time to time to ensure that a good quality of borehole water is consumed.

Conflict of Interest

The authors declared no conflict of interest

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