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Water Quality Evaluation of Hand-dug Wells in Ibadan, Oyo State, Nigeria

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Abstract

In many countries around the world, including Nigeria, access to potable water has become a mirage. Exploitation of groundwater through the construction of hand-dug wells is a major source of drinking water for majority of the populace. The need to assess the quality of water from this source to ascertain the role of well construction methods has now become imperative because of the health impacts on individuals. Random surveys of three classifications of hand-dug wells were done between June and October 2010, in Ibadan, Nigeria. One hundred and one (101) hand-dug wells were selected. A standard form was used for capturing data used for the classification of the wells into protected, semi protected and unprotected. Standard laboratory methods were employed for the analysis of electrical conductivity, pH, Temperature, Chlorides, Nitrate, E. coli and Total Coliform Count. Results show that nitrate concentration, *E. Coli* and total coliform counts are more pronounced in wells that are installed close to domestic refuse waste, abattoir, pit latrine, stagnant water, and drainages. The pronounced concentrations decreased with increasing distance from the pollution sources irrespective of well classification. Protected wells gave better water quality relative to semi-protected and unprotected wells. The paper recommends regular monitoring of groundwater quality, abolishment of unhealthy waste disposal practices, and regulation of self supply well construction and design.

Key words: Hand dug well, Groundwater, Protected well, Semi-protected well, Un-protected well

Introduction

Access to safe drinking water is a problem facing a large proportion of the inhabitant of the developing nations (UNICEF, 2005; Cosgrove and Rijsberman, 2000; Gomez and Nakat, 2002). In spite of the considerable investments of Nigerian government in water supply programme, over 52% of its population have no access to potable water (Oluwasanya, 2009). For instance in Ibadan, despite the effort of public water agency in providing potable water to the populace, the problem of acute water shortage is still dominant. Low access to safe water in Nigeria has been attributed to the enormous socio-economic development, growing industrial base, poor planning, insufficient funding and haphazard implementation, to mention a few (Oluwasanya, 2009). Consequently, the inhabitants have resulted into the use of hand-dug wells as an alternative source of water supply. Hand-dug wells also provide cheap and low-technology solution to the challenges of rural and urban water supply. Well construction too affords an opportunity for community participation during all phases of the water supply process (Seamus, 2000). Hand-dug wells could be protected, un-protected or semi-protected. A protected well is one equipped with a dedicated pump (manual or motorised), concrete lining and platform (or apron), head wall, cover and drainage channel (Murcott, 2007; Oluwasanya et al., 2011). Un-protected well is without any of the features stated above and a semi-protected well may have one or more of the features found in a protected well (Oluwasanya *et al*., 2011). Most hand-dug wells are shallow, although wells as deep as 120 metres have been reported (Watt and Wood, 1977). The wells are often more vulnerable to contamination than deeper boreholes. Whilst some shallow dug wells have mechanised pumping, the majority (particularly those in developing countries) have water abstraction through some form of hand pump, windlass or rope and bucket system (Collins, 2000). Shimizu *et al*. (1980) have shown that bacteria contaminate well water depending on location. Thus, it is suspected that water from wells in unhygienic areas could be contaminated according to their proximity to sources of pollution. Contaminants such as bacteria, viruses, heavy metals, nitrates and salts have polluted water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over-utilisation of limited water resources (Adeyemi *et al*., 2007). Contamination of well water, which has led to health risks, is known in the study area. Therefore, it becomes imperative to investigate the effect that construction pattern of hand-dug well has on water quality.

Study Area

Ibadan was derived from two words 'Eba Odan' meaning near savannah (Ayoade, 1979). The city is located in southwestern Nigeria between latitudes7^0 00^1 and 7^0 $30^'$ and between longitudes 3^0 $30^'$ and 4^0 $00^'$ (Figure 1). It is the capital of Oyo State. The city is located at about 128 km northeast of Lagos and 530 km southeast of Abuja. Its elevation ranges from 150 m above sea level (asl) in the valley to 275 m asl on the major North-South ridge (Lloyd et al., 1987). Ibadan is located within the undifferentiated basement complex and the rock types consist of quartizes of meta-sedimentary series and migmatites complex consisting of branded gneiss and auger gneiss. The minor rock type is pegmatites. The gneiss in Ibadan is strongly folated into a general strike of NNW-SSW (Adeyemi *et al*., 2007). In 2006, Ibadan had a population of 2,550,593 (National bureau of Statistics, 2006). Ibadan is continually growing in human population and this has resulted in continuous increase in water consumption demand. This situation has led to persistent water shortage in the city and its environs.

Materials and Method

One hundred and one (101) hand-dug wells were randomly selected from four Local Governments in the core area of Ibadan. The core area includes Ibadan North Local Government, Ibadan North East Local Government, Ibadan South East Local Government, and Ibadan South West Local Government (Figure 1). The selection criteria for the wells were based primarily on construction pattern and mode of operation of the wells (Table 1). Typical examples of the selected wells per classifications are shown in Figure 2. Other considerations include location in residential areas and accessibility.

Water samples at different locations collected for laboratory analysis were taken following standard procedure and immediately labelled on the field using appropriate well codes. A plastic bottle was used to collect water samples for physico-chemical analysis, while a sterilized plastic bottle kept in an insulated cold box was used to collect samples for microbial analysis. Standard laboratory methods were employed for the analysis of Electrical Conductivity, pH, Temperature, Chlorides, Nitrate, E. coli and Total Coliform Count (TTC). The information on age of well, static water level, depth of well, distance to toilet/burial site, number of users was also gathered in the study. The information was sourced either by measurement, interviews or personal observations.

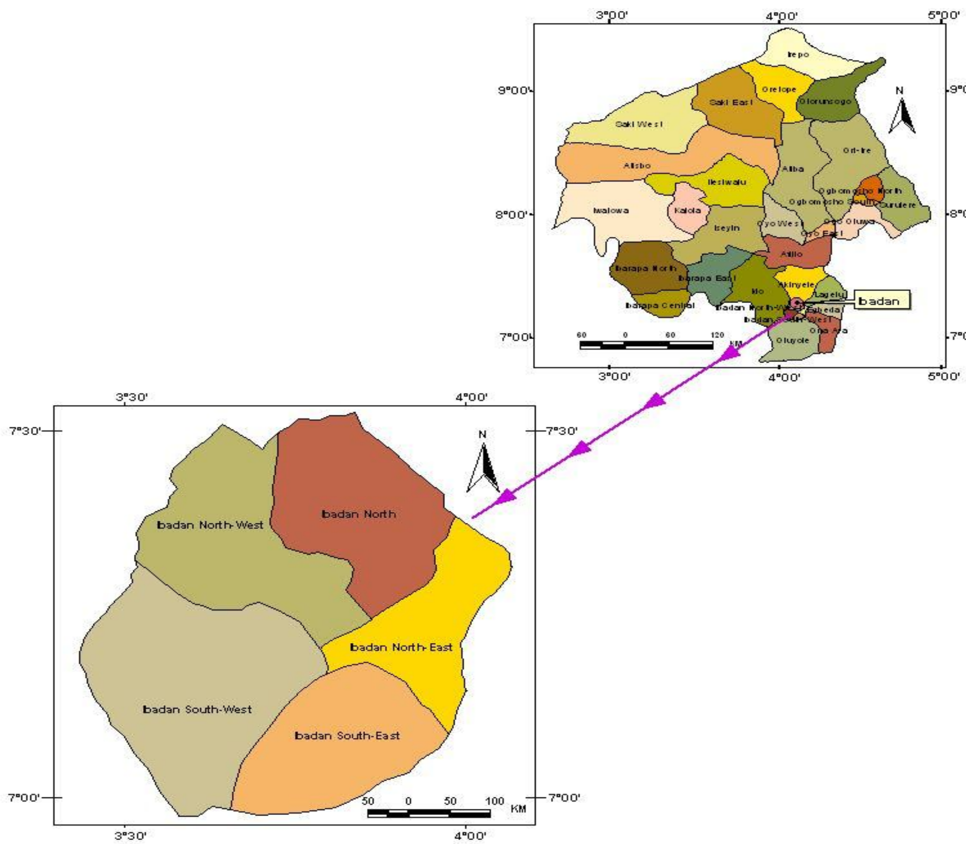

Figure 1: Map of Ibadan land showing the study Areas

Table 1: Hand-dug well classifications based on structure and mode of operation

Well Operation	Hand-Dug Well Structures				
	LCAD	LAD	CAD	LC	NONE
Pump	P^+	S	S	P	U
Bucket/Rope	P^-	S	S	S	U

Note: L: Lining, C: Cover, A: Apron, D: Drainage, P: Protected Well, +: Best practice, -: Lower level than best practice, S: Semi-protected or missing one or more construction features, U: Unprotected or missing most of/no protective feature. Source: (Oluwasanya et al., 2011)

Figure 2: Construction patterns of selected wells - a: protected well; b: semi-protected; c: unprotected well

Results and Discussions

The number of selected wells that fits into each well classification is presented in Table 2. Forty one percent (42) of the hand-dug wells are protected, 37% (37) and 22% (22) of the wells are semi-protected and unprotected respectively (Figure 3).

Table 2: Number of wells within existing well classifications, type of operation, proximity to sanitary facilities and number of users

Construction Pattern	Mode of Operation			Average Distance to Pollution Source		Average No of Users
	Pump	Pump/Bucket& Rope	Bucket & Rope	Toilet (m)	Burial Site (m)	
Protected Well	8	3	31	35.70	40.58	50
Semi-Protected Well	2	-	35	14.20	20.66	99
Unprotected Well	-	-	22	9.42	7.94	200
Total	10	3	88			

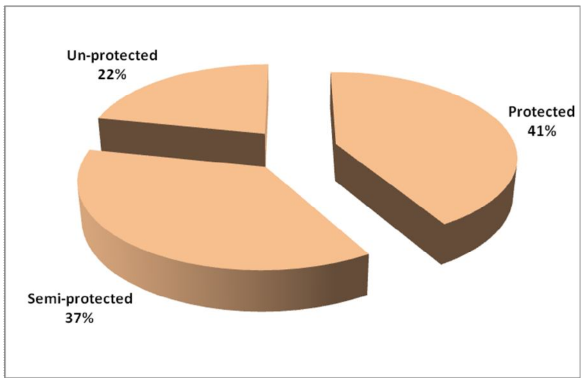

Figure 3: Construction patterns of hand-dug wells

Hand-dug Well Classification and Water Quality

The result of water analysis for different well classification is presented in Table 3. Table 3 shows that the highest average value of 869.98 µs/cm was recorded for electrical conductivity in unprotected well relative to 688.65 µs/cm and 808.46 µs/cm that was recorded in protected and semi- protected wells respectively (Table 3 and Figure 4). The recorded high EC value in unprotected wells may be due to direct ingress of water due to poor well construction. However, all of the recorded values are below the recommended value of 1000 µs/cm (WHO, 2011; NDWQS, 2007).

Table 3: Relationship between the average water quality status and hand dug well classifications

	EC (µs/cm)	pH	TEMP (^{0}C)	CHLORIDES (mg/l)	NITRATES (mg/l)	E.COLI (100ml/cfu)	TTC (100ml/cfu)
Protected Well	688.65	6.77	27.10	54.25	45.91	23.5	348.19
Semi-Protected Well	808.46	6.81	26.89	74.78	61.37	58.37	424.86
Unprotected Well	869.98	6.94	26.21	67.72	56.61	74.09	685.00
Protected Well	1000.00	6.50-8.50	27.00	200.00	50.00	0.00	10.00

The average chloride values ranges from 54.25 mg/l for protected well, 74.8 mg/l for semi protected well and 67.73 mg/l for un protected well (Table 3 and Figure 5). All this values are below the recommended WHO (2011) value of 200 mg/l for drinking water.

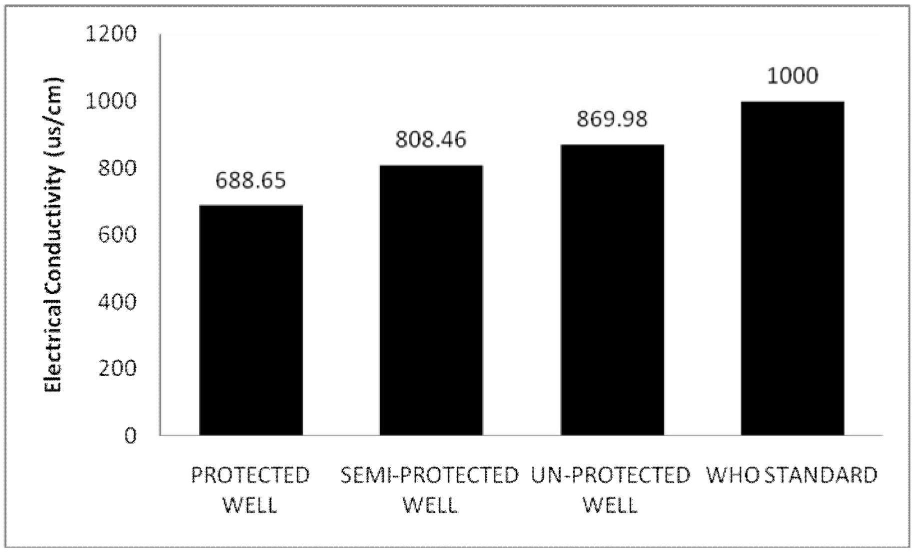

Figure 4: Average level of electrical conductivity in hand-dug wells

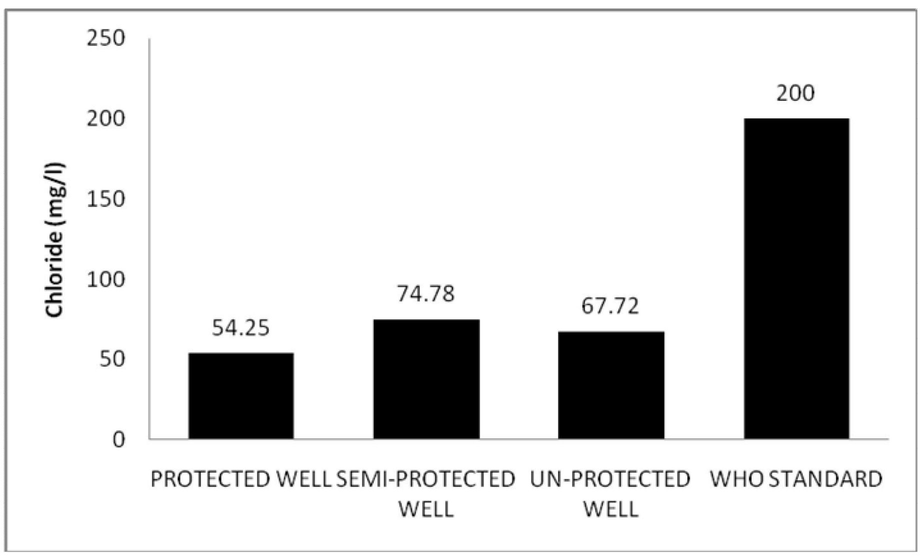

Figure 5: Average values of Chlorides in hand-dug wells

Elevated nitrate were identified in the unprotected and semi-protected samples tested, with average values of 61.37 mg/l and 56.62 mg/l respectively compared to the protected well with an average value of 43.19 mg/l (Table 3 and Figure 6). Most of the semi-protected and the un-protected wells have nitrate concentrations higher than the WHO (2011) recommended value of 50 mg/l for drinking water.

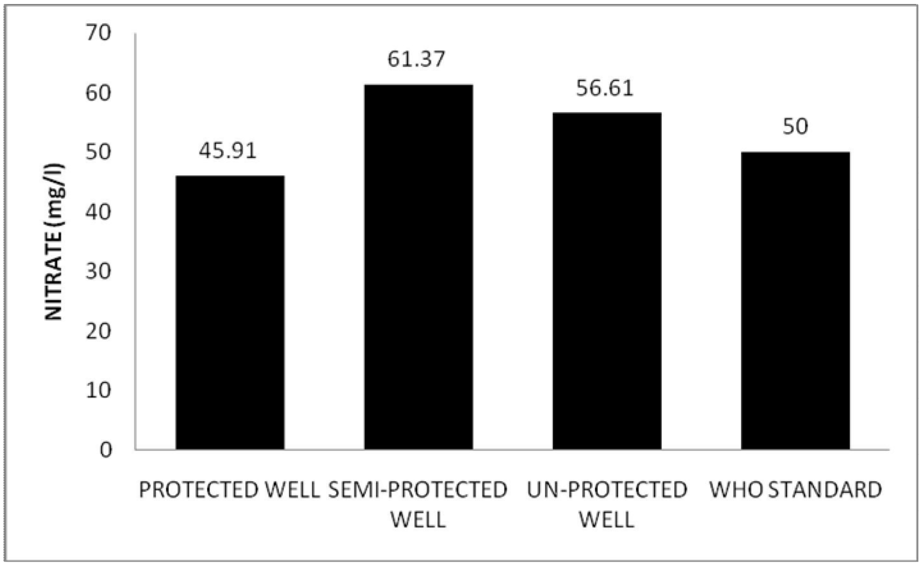

Figure 6: Average values of Nitrate in hand-dug wells

Nitrate has known human health impacts, primarily in infants. Nitrate affects haemoglobin in the blood and reduces the babies' ability to transport oxygen; infants so affected are said to have 'blue baby syndrome'. There is also a 'suspected link between exposure to nitrate and cancer in human (WHO, 2004). The most common origins of nitrate in groundwater within the study area are agricultural activities and disposal of untreated human waste.

Furthermore, the results showed that all water samples contained E. coli that does not conform to the maximum contaminant level of 0cfu/100ml. The *E. coli* in protected well ranges between 0-90cfu/100 ml, while in semi-protected and unprotected well, it ranges from 0 - 120cfu/100ml and 0 - 270cfu/100ml respectively (Figure 7).

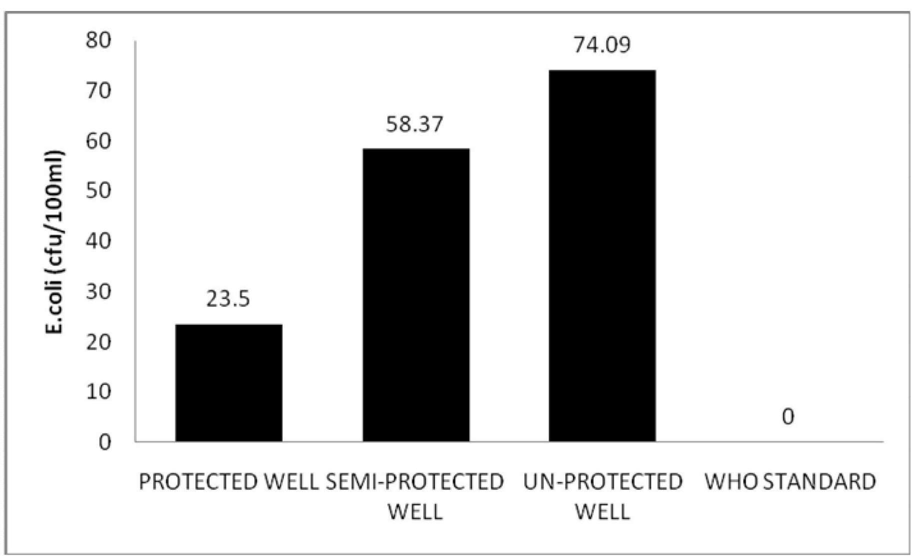

Figure 7: Average values of E. coli in hand- dug wells

Effects of the presence of E. coli in water include: Urinary track infections, bacteraemia, meningitis, diarrhea, (one of the main cause of morbidity and mortality among children), acute renal failure and haemolytic anaemia (WHO 2006).

From the result of the analysis on TTC, it was observed that all the tested samples have detectable amount of TTC, with concentration ranging from 0-1260 cfu/100 ml for protected, 120-840 cfu/100ml for semi-protected and 210-1420cfu/100ml for unprotected wells (Table 3 and Figure 8), as against the WHO (2011) acceptable limit of 10 cfu/100ml for potable water. This is an indication of faecal contamination.

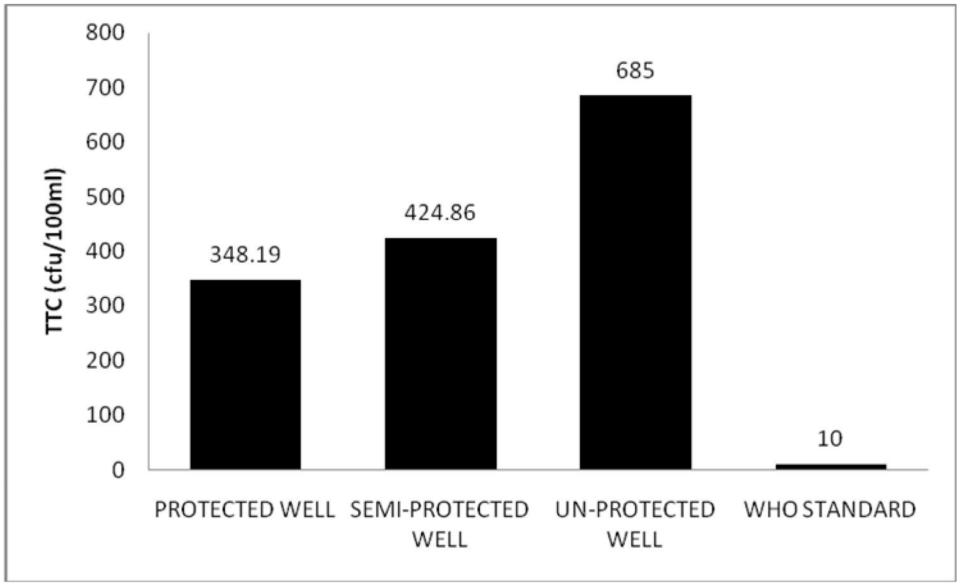

Figure 8: Average values of Total Coliform Count in hand-dug wells

Hand-dug Well Classification and Mode of Abstraction

Observations during survey shows possible surface entry contamination during abstraction because 3% of the hand-dug wells were operated with both pump and bucket & rope while 10% are operated through a motorized pump and 87% of the hand-dug wells were operated through bucket and rope gotten from different sources. This implies that high level of contamination during abstraction may be expected (Table 3 and Figure 8)

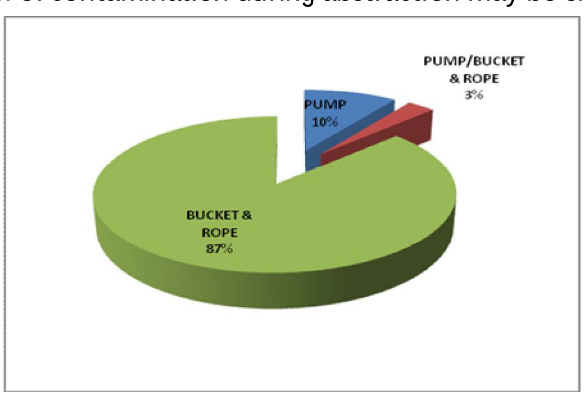

Figure 8: Means of hand-dug wells Abstraction

Poor well design and construction can also contaminate groundwater by allowing polluted surface water to reach the groundwater without filtering through soil. Wells constructed in pits, or built without being sealed or without a cap, may allow infiltration of contaminated surface water to carry bacteria, nitrates, pesticides, fertilizer, or oil into the drinking water supply. Proper well design and construction reduce this risk by sealing the well from contaminants that might enter from the surface.

Hand-dug Well Classification versus Well Location

Proper location of hand-dug well is important to water quality. Locating a well in a safe place takes careful planning and consideration of surface drainage and possible contamination sources. Generally, a well downhill of pollution source has a greater risk of contamination than a well uphill of pollution sources. Similarly, as expected and as shown in this study, the greater the distance a well is from a potential contamination source, the less likely the well will be contaminated directly by that source. The Mississippi State Department of Health requires that a new well be installed at least 15.24m from a septic tank and at least 30.5 m from the septic system drain field. These are *minimum separation distances*, and a well must be installed farther away from all pollution sources if possible. Therefore, as presented in the result above (Table 3) an unprotected well with distance 9.42 m from pollution source has a greater risk of contamination relative to the semi-protected and protected hand-dug wells with 14.20 m and 35.70 m respectively from pollution sources.

Well Age and Total Number of Users

The average age for Protected, Semi-protected and Un-protected hand-dug wells are 13 years, 32 years and 48 years respectively (Table 3). Age of well can be an important indicator of its ability to keep out contaminants. Hand-dug well of more than 70 years old is more likely to be shallower, located at the center of homestead, and surrounded by many potential contamination sources. Older well pumps are more likely to leak lubricating oils into the well. Older wells also are more likely to have thinner casing that may be corroded and allow in a contaminant. Even wells 30 to 40 years old may be subject to corrosion.

Conclusion

The paper shows that the use of bucket and rope in the abstraction of water from hand-dug wells may contribute to increase in contamination of water in the wells irrespective of the well classification. Judging the importance of each of the well category in the study area, the use of protected wells design has been proven to be the best for proper hygiene and protection of wells. However, the combined effects of installing wells close to sanitary facilities, waste dumps, industrial effluent discharge area and burial ground , contributes significantly to high pollution of wells, resulting in the deterioration of the quality and its potential public health risk. Hence, there is therefore the need for a periodic water quality monitoring and incorporation of household water treatment practices with hand-dug well water. Upgrade of semi-protected and unprotected wells is recommended, and public enlightenment on water quality is necessary to forestall potential public health treats from such sources.

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