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# HAZARD ANALYSIS OF DOMESTIC WATER SUPPLY FROM HAND-DUG WELLS IN ASIN COMMUNITY OF IKOLE EKITI LOCAL GOVERNMENT AREA

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*Pure water does not generally occur in nature because natural water (surface, precipitation or ground) all contain dissolved solids and gases as well as suspended matter. In developing countries, use of shallow groundwater sources for drinking and other domestic purposes is a common feature. This has led to a research on a comprehensive hazard analysis on selected hand dug well in Asin Community of Ikole Ekiti by analyzing the sanitary and water quality parameters that govern acceptability of water sources for domestic use. Asin-Ekiti of Ikole L.G.A was divided into zones for stratified sampling, twenty hand dug wells were selected within the zones, the criteria for the selection of wells in this community were based primarily on the construction pattern and mode of operation of the wells. Physical, Chemical and Biological tests were carried out on the water samples and results were compared with the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO) standards. All water quality analyses were conducted using the 'Standard Methods for the Examination of Water and Wastewater'. Hazard analysis was conducted by identifying potential risks in systems and proffering solutions to eliminate/ manage the risks accordingly. All Physical and Chemical parameters analyzed were within recommended limits for drinking water in domestic use except for the pH values that require pH adjustment for some selected water sources. Hazard Analysis showed that corrective measures are required in the operation of some of the selected water sources, it was therefore recommended that strict monitoring and evaluation of water quality from Hand Dug Well-4 to Hand Dug Well-20 should be maintained.*

## INTRODUCTION

Without water, life cannot be sustained beyond a few days and the lack of access to adequate quantity and quality that meets international standards leads to the spread of diseases. Children bear the greatest health burden associated with poor water quality and sanitation as diarrhoeal diseases attributed to poor water supply, sanitation and hygiene accounted for more than 500,000 under 5 years deaths in a year. (UNICEF, 2016).

This placed diarrhoeal disease due to unsafe water, sanitation and hygiene as the second leading cause of death in children under five years old; a health burden that is largely preventable (WHO, 2017). Other diseases that are related to poor water, sanitation and hygiene such as trachoma, schistosomiasis, ascariasis, hookworm disease, malaria, typhoid fever and cholera among others contribute to an additional burden of disease.

Pure water does not generally occur in nature. This is because all natural water whether surface, precipitation or ground contain dissolved solids and gases as well as suspended matter. The quality and quantity of these constituents depend on geologic and environmental factors, which continuously change as a result of the reaction of water with contact media and human activities, it is noted that 'zero-risk' scenario for domestic water supply is not achievable (Fewtrell and Bartram, 2001; Haas et al., 1999), however, water intended for domestic use must meet some standards. In its 'Guidelines for Drinking Water Quality', World Health Organization (WHO) defines domestic water as being 'water used for consumption, bathing and food preparation' (WHO, 2011). Also, productive use of water sources for activities such as animal watering, construction and small-scale horticulture (Thompson, 2001) at household level will generate income without much a-do about the water quality.

Ground water which refers to water that is extractable from saturated, highly permeable strata known as aquifers (Nwaogazie, 1985; Pritchard et al., 2008; Obuobie & Barry, 2010) can be polluted by runoff from fertilized fields, livestock areas, abandoned mines, salted roads, industrial areas and wastes disposed off around water sources (Schaffter & Parriaux, 2002). Other sources of groundwater pollution include gasoline leakage into ground water from underground storage tanks, waste water disposal systems and leachate from refuse dumps (Aderemi et al, 2011; Odia et al., 2016).

The use of unimproved drinking water sources is a major cause of health challenges (Cairncross and Feachem, 2005), coupled with uncontrolled siting of latrines. Sanitation facilities which are appropriate to meet the needs and demands of communities at affordable cost both at construction and operation and maintenance for end users are viable options to the control of contamination of domestic groundwater sources. Factors such as the presence of uncapped wells and poor sanitary completion of the wells, negatively impacts on water bodies as studies on domestic water quality from some hand dug wells have shown (Ayodele and Aturamu, 2011). In developing countries, use of shallow groundwater sources for drinking and other domestic purposes is a common feature of many low-income communities (Howard *et al.,* 2003).

This research was therefore aimed at conducting a comprehensive hazard analysis on selected hand dug well in Asin Community of Ikole Ekiti by analyzing the sanitary and water quality parameters that govern acceptability of water sources for domestic use.

## METHODOLOGY

Study Area

Asin-Ekiti community is situated in Ikole-Ekiti, Nigeria. It is located in south-western Nigeria on longitude7° 47′ 0″ North and latitude 5° 31′ 0″ East. The predominant mother tongue spoken in Asin-Ekiti of Ikole, Ekiti State is Yoruba. It has an area of 321 $km^2$ and a population of 168,436 at the 2006 census (NBS, 2007). Asin-Ekiti of Ikole Local Government Area is situated in the deciduous forest area of the State. Rainfall is about 70 inches per annum, rain falls between March and November of the year. The good drainage of the land makes it very suitable for agricultural pursuits. It is a common feature that trees shed their leaves every year during the dry season which begins in November and ends in February. The two seasons – Dry Season (November - February) and Rainy Season (early March – November) are quite distinct and they are very important to the agricultural pursuits of the people.

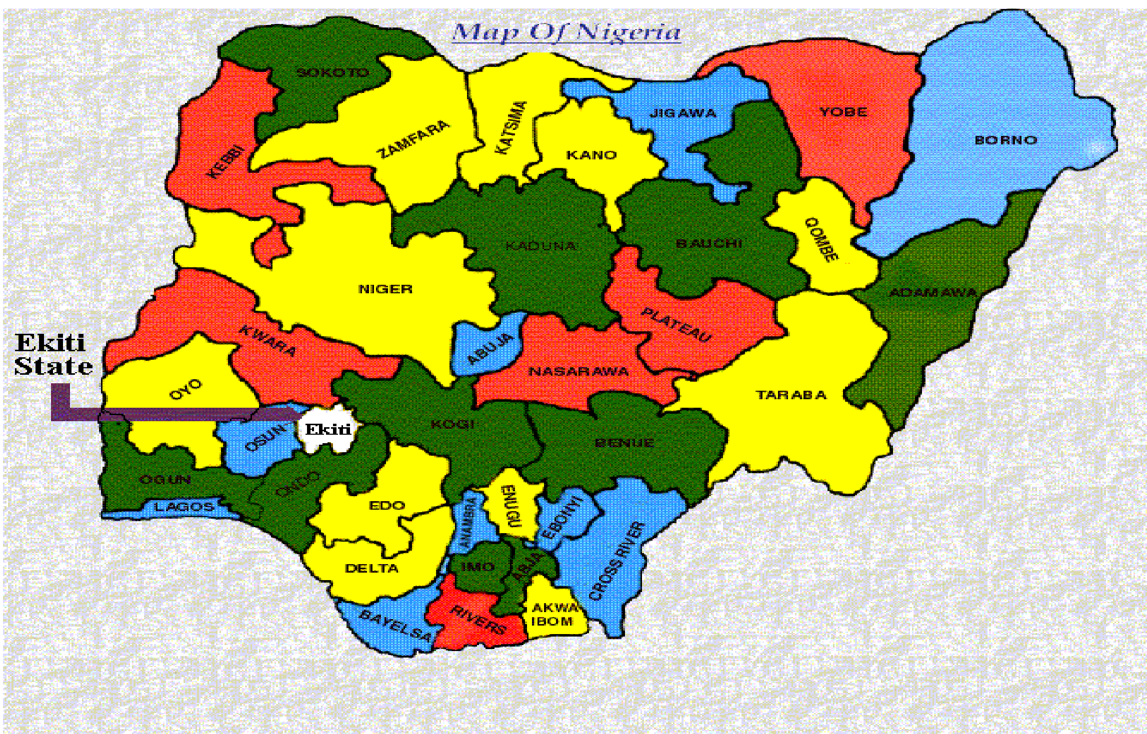


Figure 1. Map of Nigeria showing Ekiti State.

Sampling Area

Asin-Ekiti of Ikole L.G.A was divided into zones based on street locations for stratified sampling, twenty hand dug wells were selected from the eight (8) streets, with selection of two hand-dug wells from four streets (A-D) and three hand-dug wells from another four streets (E-H) as shown in Table 1.

The criteria for the selection of wells in this community were based primarily on the construction pattern and mode of operation of the wells. The construction pattern, mode of operation of selected hand dug wells on different streets and the Global Positioning System (GPS) Location of Selected Hand Dug Wells (HDW) is presented in Table 1.


Figure 2. Map of Ekiti State showing all Local Government Area of the State.

Domestic Water Samples were collected from the selected twenty hand-dug wells within Asin community area of Ikole L.G.A. The sample bottles for collection were sterilized before use. Physical, Chemical and Biological tests were carried out on the water samples and results were compared with the Nigeria Standard for Drinking Water Quality (NSDWQ, 2007) and World Health Organization (WHO, 2011) standards. All water quality analyses were conducted based on the 'Standard Methods for the Examination of Water and Wastewater' (APHA, 1999).

## RESULTS AND DISCUSSION

Hazard Analysis

Hazard analysis was conducted by identifying potential risks in systems and proffering solutions to eliminate/ manage the risks accordingly. Table 2 presents the various types and sources of hazards considered.

## RESULTS

From the laboratory analyses of water samples, the following results were obtained as presented in Tables 3 – 5.

Table 1. Name, Construction pattern, Mode of operation and Location of Selected Well.

| Zone | Street Name | Construction pattern | Mode of operation | Hand Dug Well(HDW) Code | GPS Location |
|---|---|---|---|---|---|
| A | Akintola Street | Semi-protected | Bucket and rope | HDW1 | 7.475990$^0$N 5.295354$^0$E |
| | | | | HDW2 | 7.475998$^0$N 5.295213$^0$E |
| B | DS Ajayi Street | Well protected | Bucket and rope | HDW3 | 7.475926$^0$N 5.294660$^0$E |
| | | | | HDW4 | 7.476339$^0$N 5.294772$^0$E |
| C | PA John Olatuyi street | Well protected | Bucket and rope | HDW5 | 7.4732030N 5.2943440E |
| | | | | HDW6 | 7.472311$^0$N 5.293932$^0$E |
| D | Emmanuel Adeyemo street | Semi-protected | Bucket and rope | HDW7 | 7.472193$^0$N 5.293594$^0$E |
| | | | | HDW8 | 7.472190$^0$N 5.293486$^0$E |
| E | Mic-Vic Hotel street | Semi-protected | Bucket and rope | HDW9 | 7.473681$^0$N 5.294868$^0$E |
| | | | | HDW10 | 7.473447$^0$N 5.294611$^0$E |
| | | | | HDW11 | 7.473731$^0$N 5.294403$^0$E |
| F | Ona Iye street | Well-protected | Bucket and rope | HDW12 | 7.475558$^0$N 5.294668$^0$E |
| | | | | HDW13 | 7.475727$^0$N 5.294488$^0$E |
| | | | | HDW14 | 7.474591$^0$N 5.293986$^0$E |
| G | Ifesowapo street | Semi-protected | Bucket and rope | HDW15 | 7.474767$^0$N 5.294819$^0$E |
| | | | | HDW16 | 7.474886$^0$N 5.294339$^0$E |
| | | | | HDW17 | 7.474535$^0$N 5.294824$^0$E |
| H | Palace Way | Semi-protected | Bucket and rope | HDW18 | 7.473879$^0$N 5.295811$^0$E |
| | | | | HDW19 | 7.472324$^0$N 5.295333$^0$E |
| | | | | HDW20 | 7.471733$^0$N 5.295084$^0$E |

Table 2. Identification of Sources of Hazards

| **Hazardous event** | **Associated hazards (and issues to consider)** |
|---|---|
| Contaminants in Vicinity of Water Source (Refuse Dump Sites) | Contamination of domestic water |
| Location of septic tanks | Microbial contamination |
| Hand dug Well without headwork, Platform, Drainage, Lining | Runoff/overland flow seepage |
| Flooding around water source | Contaminated water infiltrates and percolates to water table |

Table 3: Results of Physical Parameters of Collected Water Samples for HDWs 1-20.

| **PARAMETER** | HDW1 | HDW2 | HDW3 | HDW4 | HDW5 | HDW6 | HDW7 | HDW8 | HDW9 | HDW10 | WHO | NSDWQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEMP ($^oC$) | 26.2 | 26.7 | 26.0 | 26.3 | 26.2 | 26.4 | 26.2 | 26.4 | 27.0 | 26.3 | AMBIENT | AMBIENT |
| COLOR (TCU) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 15 |
| TDS (mg/l) | 0.52 | 0.42 | 0.40 | 0.47 | 0.55 | 0.43 | 0.54 | 0.29 | 0.36 | 0.46 | 1000 | 500 |
| TASTE AND ODOR | UN-OBJ$^{\pm}$ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ |
| **PARAMETER** | HDW11 | HDW12 | HDW13 | HDW14 | HDW15 | HDW16 | HDW17 | HDW18 | HDW19 | HDW20 | WHO | NSDWQ |
| TEMP ($^oC$) | 27.8 | 26.4 | 28.5 | 26.4 | 28.0 | 28.4 | 28.7 | 28.2 | 28.4 | 28.7 | AMBIENT | AMBIENT |
| COLOR (TCU) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 15 |
| TDS (mg/l) | 0.74 | 0.77 | 0.69 | 0.54 | 0.70 | 0.68 | 0.72 | 0.65 | 0.64 | 0.59 | 1000 | 500 |
| TASTE AND ODOR | UN-OBJ$^{\pm}$ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ | UN-OBJ |

Table 4: Results of Chemical Parameters of Collected Water Samples for HDW1 – 20.

| PARAMETER | HDW1 | HDW2 | HDW3 | HDW4 | HDW5 | HDW6 | HDW7 | HDW8 | HDW9 | HDW10 | WHO | NSDWQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 5.64 | 5.61 | 5.93 | 5.38 | 5.99 | 6.83 | 6.74 | 6.74 | 6.63 | 5.54 | 6.5-8.5 | 6.5-8.5 |
| Chloride, (mg/l) | 6.00 | 5.00 | 5.80 | 4.40 | 5.40 | 6.50 | 5.60 | 5.20 | 4.50 | 4.60 | 250 | 250 |
| Copper (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Total Hardness (mg/l) | 15.20 | 14.40 | 15.60 | 16.40 | 16.00 | 12.00 | 11.20 | 18.80 | 16.10 | 15.20 | 75 | 150 |
| Nitrate (mg/l) | 0.86 | 0.53 | 0.90 | 0.88 | 0.92 | 0.90 | 0.96 | 0.94 | 0.83 | 0.78 | 50 | 50 |
| Sulphate (mg/l) | 28.40 | 28.10 | 29.20 | 29.60 | 28.50 | 26.80 | 25.90 | 30.20 | 29.30 | 29.10 | 200 | 100 |
| Zinc (mg/l) | 0.36 | 0.26 | 0.21 | 0.30 | 0.31 | 0.37 | 0.34 | 0.38 | 0.35 | 0.40 | 3 | 3 |
| Conductivity (µS/cm) | 88.20 | 53.80 | 181.30 | 96.80 | 0.61 | 0.69 | 0.66 | 0.72 | 0.65 | 0.78 | 1400 | 1000 |
| PARAMETER | HDW11 | HDW12 | HDW13 | HDW14 | HDW15 | HDW16 | HDW17 | HDW18 | HDW19 | HDW20 | WHO | NSDWQ |
| pH | 7.31 | 6.27 | 6.89 | 6.64 | 6.22 | 6.10 | 7.00 | 7.04 | 7.14 | 7.21 | 6.5-8.5 | 6.5-8.5 |
| Chloride, (mg/l) | 6.00 | 4.80 | 6.20 | 5.50 | 6.00 | 5.90 | 8.20 | 7.10 | 4.80 | 6.50 | 250 | 250 |
| Copper (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Total Hardness (mg/l) | 16.00 | 11.60 | 12.80 | 14.40 | 13..70 | 18.40 | 13.60 | 17.20 | 18.00 | 16.80 | 75 | 150 |
| Nitrate (mg/l) | 0.97 | 0.99 | 0.95 | 0.85 | 0.92 | 0.96 | 0.98 | 0.96 | 0.94 | 0.89 | 50 | 50 |
| Sulphate (mg/l) | 28.70 | 26.00 | 27.10 | 28.30 | 29.20 | 30.00 | 26.50 | 29.40 | 29.90 | 28.90 | 200 | 100 |
| Zinc (mg/l) | 0.36 | 0.41 | 0.40 | 0.39 | 0.42 | 0.38 | 0.42 | 0.43 | 0.41 | 0.39 | 3 | 3 |
| Conductivity (µS/cm) | 173.60 | 261.00 | 148.10 | 150.40 | 208.60 | 268.50 | 251.60 | 311.50 | 153.00 | 101.80 | 1400 | 1000 |

Table 5 presents the results of the Bacteriological parameter for selected hand dug wells.

Table 5. Result of Bacteriological Parameters of samples from HDW1 – 20

| PARAMETER | HDW1 | HDW2 | HDW3 | HDW4 | HDW5 | HDW6 | HDW7 | HDW8 | HDW9 | HDW10 | WHO | NSDWQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total coliform count (cfu/ml) | 10.0 | 10.0 | 10.0 | 14.0 | 20.0 | 25.0 | 22.0 | 34.0 | 32.0 | 31.0 | 0 | 10 |
| **PARAMETER** | **HDW11** | **HDW12** | **HDW13** | **HDW14** | **HDW15** | **HDW16** | **HDW17** | **HDW18** | **HDW19** | **HDW20** | **WHO** | **NSDWQ** |
| Total coliform count (cfu/ml) | 29.0 | 30.0 | 31.0 | 29.0 | 32.0 | 30.0 | 31.0 | 29.0 | 27.0 | 26.0 | 0 | 10 |

**Hazard Analysis of Selected Water Sources**

Table 6 presents the results of the Hazard Analysis for selected wells.

Table 6. Analysis of Hazard Event (Refuse Dump Sites & Pit Latrine/Septic Tanks)

| Hazard Event | Water Source | Associated Hazard | Cause | Risk | Critical Limits | | Corrective Action | Monitoring | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Current Situation | Target | | What | When | Who |
| Contaminants in Vicinity of Water Source | HDW 1 to HDW3 | Microbial Contamination | - | No Observed Risk | Acceptable | | None | Solid Waste Disposal | Weekly | Designated Personnel |
| | HDW4 to HDW20 | Microbial Contamination | Refuse dump sites less than 30m from water source | High Risk | Not Acceptable | Refuse dump sites distance greater than 30m radius of water source | Stop solid waste disposal within 30m radius of water source | | | |
| Location of Pit latrine/ Septic Tank from Water Source | HDW 1 to HDW12 HDW14 to HDW18 HDW20 | Microbial Contamination | Facility Location | No Observed Risk | Acceptable | | None | Location of Pit latrine/ Septic tank from water source | Bi-Annually | Designated Personnel |
| | HDW13 and 19 | Microbial Contamination | Facility Location | Risk Observed | Not Acceptable | Locate water source at least 30m from contaminants | Relocate Water Source | | | |

# DISCUSSION

Based on the results from the water sample analysis of the Physical, Chemical and Biological parameters, it was found that the on-site temperature of water samples obtained from twenty hand-dug wells in Asin-ekiti of Ikole LGA ranged between 26.0°C and 28.7°C. The pH of samples from HDW 1,2,3,4,5,10,12,15 and 16 were slightly below NSDWQ/WHO limit, this result can still support organic life as there is practically no geological environment where the pH condition will not support some form of organic life (Chilton and West, 1992), research has also shown that values of pH higher than the recommended will hasten scale formation in water heating apparatus and reduce germicidal potential of chlorine (Kumar,2002).

The Conductivity, Chloride, Nitrate, Hardness, Sulphate, Zinc and Copper of all the samples were within NSDWQ/WHO recommended limit. It has been found that large concentrations of Chloride will increase the corrosiveness of water and, in combination with sodium, give water a salty taste (USEPA, 1994), while hardness in water has been attributed mainly to Calcium and Magnesium, for groundwater possible from the geological formation of the water bearing strata (Patel & Sinha, 1998). Sampled water sources are free from excessive chemical parameters.

The Total Coliform count of water sample from HDW1, 2 and 3 were within NSDWQ recommended limit but all the remaining samples were above recommended limit. Total Coliform count does not strictly imply fecal contamination, detailed examination will be required to determine source of contamination in the water samples.

The Hazard analysis based on location of refuse dump sites show that HDW1, 2, and 3 met the distance requirement for locating water sources from possible contaminants , corrective measured distances were proffered for the remaining seventeen sources as seen in Table 6. Analysis based on location of latrines/ septic tanks shows that sources met the minimum requirement of a distance of at least 30m from a latrine/ septic tank location except for water sources HDW13 and 19, this results in concentrations of higher levels of contaminants in the groundwater supplies than recommended limits with adverse effects on health (Moyer, & Morita, 2000). Detailed observation of the Water sources show that all the twenty water sources had acceptable construction completion with proper platforms and drainages.

## CONCLUSION AND RECOMMENDATION

### Conclusion

The use of multiple barrier technique to minimize contamination of water sources by first protecting water source will reduce the need for domestic water treatment, hazard and water quality analysis of water sources thereby supports the multiple barrier principle, from this research, the following conclusions are made:

Water sample from HDW1,2,3,4,5,10,15 and 16 show low pH values. There is need for pH adjustment to meet standards for domestic use.

Chemical parameters of water samples are within acceptable limits for domestic water use.

The total coliform count of all water samples were above acceptable limit apart from results obtained for samples from HDW1, 2 and 3. The hazard analysis of all polluted water sources indicated the need for corrective measures to be carried out.

The corrective measures recommended for water sources with high risks require monitoring at frequent intervals.

Community awareness on sanitation around all domestic water sources should be promoted to build capacity of end users of the water facilities.

### Recommendation

It is recommended that:

The pH of water samples that are below acceptable limit should be adjusted accordingly to meet stipulated standard for domestic use.

Strict monitoring and evaluation of water quality from HDW4 to HDW20 should be maintained.

Regular monitoring of domestic water quality should be maintained for all the domestic water sources.

Strict adherence to basic environmental sanitation rules should be observed around all the domestic water sources

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