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The quality of groundwater resources around auto-mechanic workshop enclaves in Ghana

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A B S T R A C T

Water is one of the most indispensable resources and is the elixir of life. Water constitutes about 70% of the body weight of almost all living organism. It serves as the medium for both chemical and biochemical reactions and also as an internal and external media for several organisms. About 97.2% of water on earth is saline and only 2.8% is present as fresh water. Out of the about two percent freshwater resources, about 74% is found in icecaps, icebergs and glaciers. About 25% of earth's freshwater resources are found in rock fractures below the ground surface (groundwater) leaving less than one percent for surface water resources. Some human activities such as construction, farming, quarrying, sand winning, logging and the like have threatened the sources of major water bodies. The groundwater resources have become threatened by the dumping of waste materials in excavated pits. With the availability of freshwater becoming a major global challenge, this research aims at assessing the quality of hand-dug wells around auto-mechanic enclaves in Ghana. The research considered the physico-chemical and microbiological compliance of the water from these hand-dug wells to water quality standards. Through site visits, interviews and laboratory analyses of samples, the research revealed that the pH, conductivity, temperature of the samples were within approved standards. Due to the presence of coliforms in the samples, it is recommended that the hand-dug wells should be treated regularly to prevent an epidemic.

1. Introduction

Water is one of the most indispensable resources and is the elixir of life . Water constitutes about 70% of the body weight of almost all living organism. It act as a media for both chemical and biochemical reactions and also as an internal and external media for several organisms. According to Rajankar et al (2009), about 97.2% of water on earth is salty and only 2.8% is present as fresh water.

Out of the about two percent freshwater resources, about 74% is found in icecaps, icebergs and glaciers. About 25% of earth's freshwater resources are found in rock fractures below the ground surface (groundwater) leaving less than one percent for rivers, lakes, streams, soil moisture etc (Kharagpur, 2008).

A third of the world's population lives in water stressed countries, this may rise to two-third by the year 2015(Kirby, 2004, para.7). In the developing world about 25% of people lack access to safe drinking water (Gadgil,1998).

In Ghana however, only about 52% of the population has access to safe drinking water (GPRS II(2005)). In an effort to solve this problem, Ghana's growth and poverty Reduction strategy II (2005) (GPRS II – 2006 – 2009) prescribe steps to achieve the United Nation's (UN) millennium development goals on water.

1.1. Groundwater resources

Groundwater is globally very important for the development of humans. Changes in quality and quantity, with subsequent contamination can have an effect on human health. Notwithstanding, groundwater remains one of the most reliable sources of quality water and year round supply of water for human consumption and use (Appelo and Postma, 2003).

According to World Water Development Report (2012), the benefits of groundwater resources are mostly taken for granted. Water supply especially to urban centres is based on treating of polluted surface water. The cost of treating surface water has been increasing over the years. Groundwater is affordable and is closer to communities that can manage it very well.

1.2. Groundwater fundamentals

1.2.1. Water in the subsurface

Water in the subsurface occurs as part of the water profile, a section through the ground from the land surface to the rocks forming the geological basement (Figure 1.1). Water below the ground may be considered subsurface water, interstitial water or vadose water (SCCG, 2006).

Groundwater originates from water coming into contact with the land surface. As water infiltrates into the ground, it passes through the topsoil where a small part is retained as soil water. This water is the component that provides essential moisture to plants. Water descending further passes into an unsaturated zone. The unsaturated zone is dominated by the presence of air in pore spaces within the soil or rock (SCCG, 2006).

This part of the profile contains vadose water and is known as the vadose zone. Water continuing to pass through (or percolate through) the unsaturated zone under the influence of gravity reaches a level at which the pore spaces in the soil or rock are saturated. This level represents the boundary between the unsaturated and saturated parts of the profile and is known commonly as the water table or phreatic surface.

The capillary zone is the zone that lies immediately above the water table. The physical attraction or suction pressure generated in the capillary zone can attract water above the phreatic level without fully saturating the pores. The thickness of the capillary zone varies and the variability depends on the aquifer characteristics. Driscoll (1986) cited in SCCG (2006) reported that the capillary zone can be up to three (3) metres.

Immediately beneath the water table is the saturated zone. Groundwater is found within the saturated zone. Depending on the hydraulic characteristics and the nature of materials that that hold the groundwater, the groundwater in the saturated zone varies. Not all of the groundwater in this zone can be extracted. Some small portion remains due to molecular forces, even during pumping (SCCG, 2006).

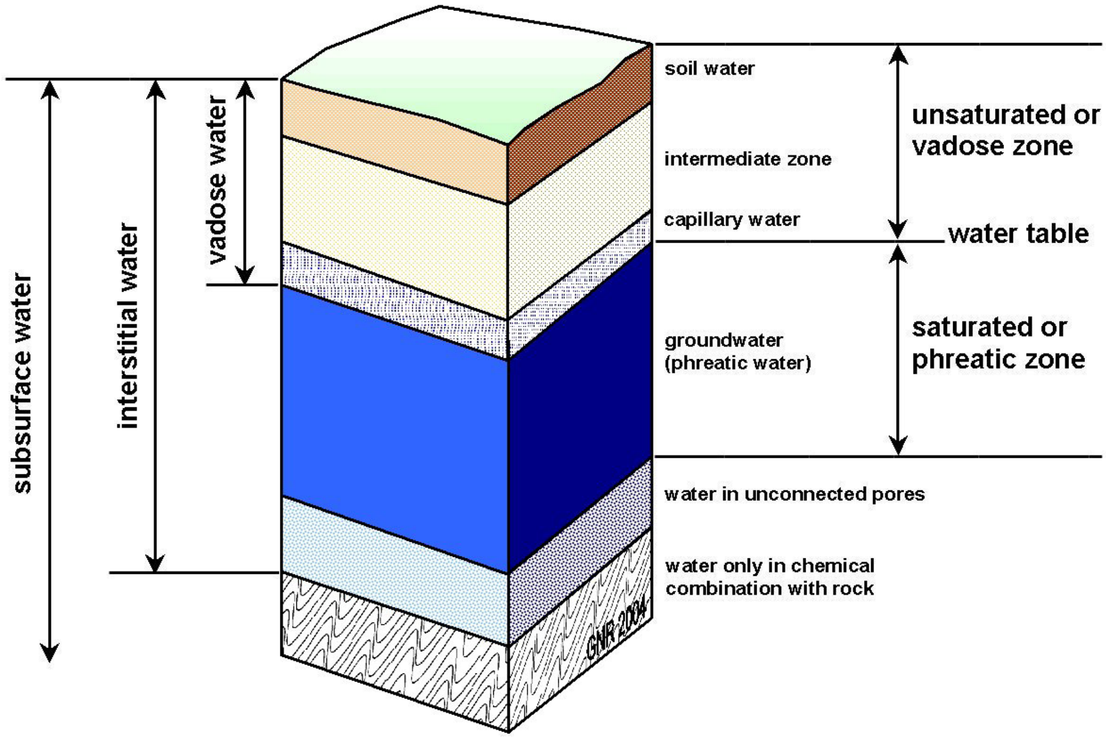

Fig. Error! No text of specified style in document..**1.** The water profile (modified from: Driscoll 1986, Domenico and Schwartz 1990).

1.3. Hand-dug wells

Watt and Wood (1977) defined a hand-dug well as the well made by excavating with hand tools or power machinery instead of by drilling or driving. It is the traditional method of obtaining ground water in the rural areas of developing world, and still the most common, is by means of hand-dug wells. Most hand-dug wells are shallow (typically 20m or less in depth) although wells as deep as 120m have been constructed (Watt and Wood, 1977).

They are often more vulnerable to contamination than boreholes, thus while some shallow wells have mechanized pumping, the majority (particularly those in developing countries) have water abstraction through some form of hand pump, windlass or rope and bucket system. A typical design is shown in Figure 1.2 below.

Some human activities such as construction, farming, quarrying, sand winning, logging and the like have threatened the sources of major rivers and streams. Most of these water sources are exposed to the elements of the weather leading to drying in the dry season. Some major water bodies have been found out to dry up during the dry seasons (Inconvenient Truth, 2006).

The complex problem of acute water supply has resulted in widespread use of hand-dug wells in major cities in Ghana especially around Auto mechanic Enclaves and its environs as an alternate source of drinking. The hand-dug wells in these areas are sometimes bedevilled with bad odour, colour change, bad taste, skin related diseases resulting from certain microbiological activities in the area and the possible leachate from the refuse and other waste related damp sites.

The aim of this research is to assess the quality of hand-dug wells around auto-mechanic enclaves in Ghana. The research further seeks to find solutions to the challenges that may arise from the quality-related issues of the hand-dug wells.

The objectives of this study include the following;

Determine the physic-chemical quality of hand-dug wells in Auto-mechanic enclaves in Ghana.

Determine the possible source of pollutants and their respective effect in the hand-dug wells.

Recommend treatment methods the identified groundwater contaminants.

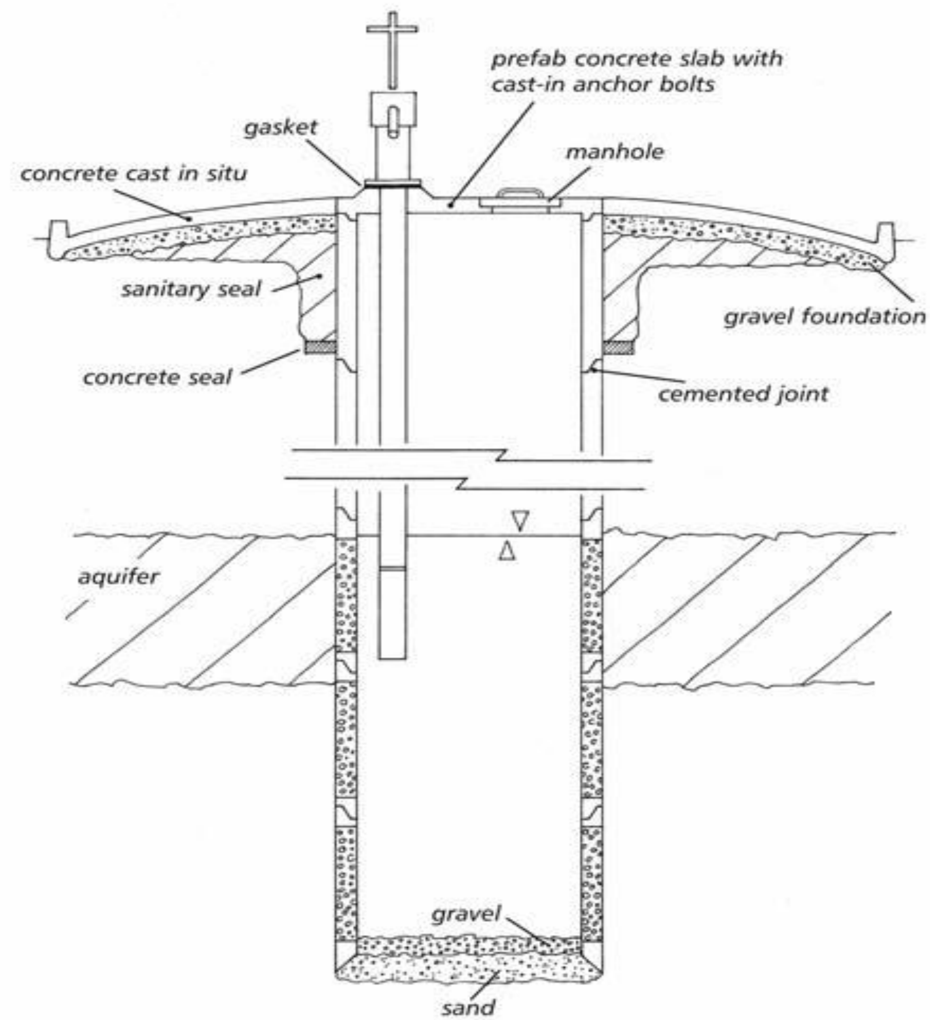

Fig. Error! No text of specified style in document.**.2.** Design of a dug well with hand pump.

Water is the most important element for our body. Water is everywhere as part of the biological processes that take place in our body at the cellular level and as such is necessary for consumption and hygiene. Water should satisfy human needs not only on the quantity but also the quality of healthcare.

Water supply is an important process residents but also costly. Many diseases transmitted through water. According to WHO (WHO, 2004) waterborne diseases by drinking about 5 million children die annually and ill sixth of the world population (Shittu O.B., et al. 2008). The high volatility of hydro diseases requires significant commitment to the consumption of safe drinking water safe in terms of health. The only safe water is the water that does not contain microorganisms or chemicals above the permitted levels. WHO and other institutions (EU, FAO EPA) to deal with this issue require drinking water to meet certain standards, where its constituent components behave within levels that do not cause damage to the body (WHO, 2004; EU Council. 1998).

Dragash lands located in the south of Kosovo and includes an area of 543 km2, where live 33 997 inhabitants, distributed in 35 villages (Census in Kosovo. 20112). This territory lies at an average altitude of 1050 m and is mostly mountainous views, rich with multiple sources of water (Dragash, 2012). All the villages in this area have built water reservoir, which accumulates in drinking water before it enters the distribution networks to family fountains. Someone has even catchments villages in the neighborhood level. Drinking water accumulated from natural sources, leakage of small rivers and catchments. Drinking water supply in local networks with distributed free fall and only in one case or two pumps water pumps used. Klorinohej drinking water in the town of Dragash only, while all other systems introduced in the distribution network without any pretreatment. In terms of water collection, storage and distribution process towards household fountains performed without any special supervision and professional. This situation assumes the risk to drinking water and its quality. The aim of the study is to assess the quality of drinking water in rural area, having Dragash and his safety health aspect, exploring and microbiological parameters fizikokimik it.

2. Results

The data obtained from the field is analysed and discussed below.

2.1. Analysis for Respondent

The genders of the respondents are shown in table 3.1 below:

Table 3.1
Gender distribution of respondents.

S/N	Gender	Number	Percentage (%)
1	Male	68	73
2	Female	25	27
	TOTAL	93	100

From table 3.1 above, about 73% of the respondents were males whiles 23% of the respondents were females. The above gender distribution indicates that the auto-mechanic business is male-dominated.

The ages of the respondents were between fifteen years and sixty-five years. The younger ages (between 15 and 25 years) represent those under apprenticeship. Some of the respondents whose ages ranged between 26 and 35 were apprentices who have graduated and were offering helping hands to their trainers. The respondents whose ages were above thirty-five were shop owners who train the apprentices the rudiments of their trade.

From the interviews conducted, the highest education level of the respondents encountered was Senior Secondary School Leavers. Some of the respondents had not being to school before.

All the respondents indicated that they have been using the selected hand-dug wells around their enclaves for their basic activities. They complained of the inconsistent flow of tap water hence forcing them to depend on the hand-dug wells.

2.2. Physical Assessment of the Hand-dug wells

It was observed from visits to the various enclaves that, different materials were used in covering the hand-dug wells. The idea is to protect the water resources in the well against the elements of the weather. Table 3.2 presents some of the materials used for covering the wells.

Table 3.2
Materials used in covering the hand-dug wells.

S/N	Materials used for well cover	Percentage (%)
1	No cover	25
2	Metal Plate	20
3	Concrete slab with metal opening	55
	TOTAL	100

From table 3.2 above, 25% of the hand-dug wells were without cover and hence open to any form of contamination. The wells with metal plates may also have their lids rusting and hence introducing contaminants to the water resource in the hand-dug well. Figure 3.1 shows location of wells and their covers

3.2.1. Proximity of hand-dug well from potential contamination sites

Site visits and interviews with the stakeholders revealed that about fifty percent (50%) of the wells in the enclaves have been located in areas that are potential contamination sites. The locations of the hand-dug wells are shown in figure 3.1 below. The wells located in the centre of houses stood the chance of minimal contamination.

Figure 3.2 indicates that about 50% of the wells are located in areas that have the potential to contaminate the water in the wells.

The respondents indicated that some of the wells were located in areas that have relations with refuse damp sites (30%), close to gutters, as well as septic tanks (9%).

About 92.3% of the respondents use water from hand-dug wells for their daily activities – except drinking- due to the non-availability of pipe borne water in most of the areas around the auto-mechanic enclaves and the remaining do not use the well water because they are fortunate to have access to pipe borne water.

The table 3.3 above shows whether there is any abnormal taste in the water. From the table 3.3, 65% says that the water is having taste and 35 % says that there is no taste in the water. The taste observed by some of the respondents implies that the water from the well have some infections, that require treatment before usage.

Fig. Error! No text of specified style in document..**3.** Location of hand-dug wells and their covers.

2.2.2. Colour

about 45% of the respondents indicated that they observed some form of coloration in the water drawn from the wells. The rest of the respondents reported of no colour changes. According to the GSB (2009), water for consumption should be colourless. The reported presence of colour in the water from the wells prompted further tests on the quality of the water and remedial measures to curb the coloration problems.

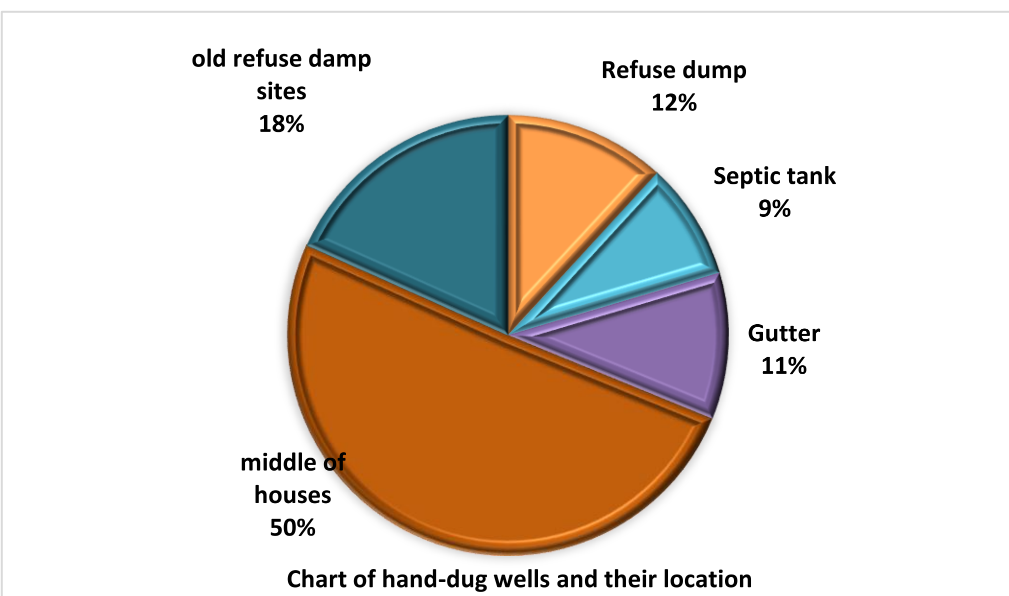

Fig. Error! No text of specified style in document..**4.** Hand-dug wells and their location.

2.2.3. Oil Traces

Oil traces were reported by about 27% of the stakeholders contacted. About 73% of the respondents did not complain of any traces of oil. Table 3.4 shows the responses provided by the stakeholders.

Table Error! No text of specified style in document.**.3**
Oil Traces in Hand-dug wells

S/N	Oil Traces Observation	Percentage (%)
1	No Trace	27
2	Trace	73
	TOTAL	100

Due to the activities undertaken around the enclave, oil spills – petrol, diesel, engine oils – occur on daily basis. These oils infiltrate and subsequently percolate into the sub-surface. This phenomenon has the potential of introducing oil traces to the groundwater system especially in the unsaturated zone.

3.3.4. Water Treatment

In response to treatment of the wells, all the respondents confirmed that the hand-dug wells were treated. The rate of treatment varied from weekly to yearly. Figure 3.3 below shows the frequency at which water is treated by the owners.

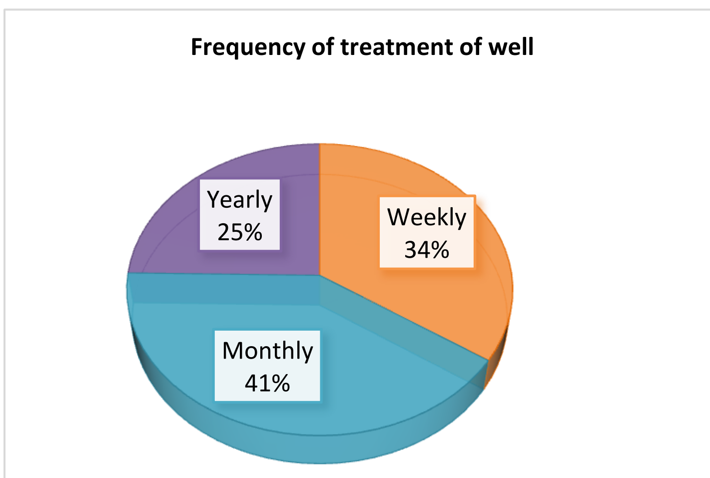

Fig. 3.5. Frequency of the hand-dug well treatment.

About 41% of the treat their wells on monthly basis. They indicated that the chemicals for the disinfection are obtained from the Ghana Water Company Limited (Water Quality Lab). About 34% of the respondents showed their interest in maintaining the quality of the water in the well hence the disinfection done weekly.

2.4. Water Quality Test Results and Analysis

Due to some water quality challenges encountered in the initial interaction with the stakeholders of the hand-dug wells, samples of water from the wells were taken to the laboratory for further assessment.

The tests were carried out in the Ghana Water Company Limited Water Quality laboratory at Sunyani and Koforidua. The test results were compared with the Ghana Water standards and the World Health Organization (WHO) standards. The above set of guidelines helped to ascertain whether the parameters in each of these ground water falls within the tolerable limit.

The average results of the water quality analysis from the laboratory are summarised in table 3.5 below. A total of thirty-five (35) samples were taken to the laboratory and the results were grouped into eight averages.

Table Error! No text of specified style in document..**4**
Summary of Water Quality Analysis.

Parameters	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**WHO limits**
PH (Mg/l)	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.7	6.5-8.5 Mg/l
Temperature °C (Mg/l)	25.0	26.5	26.6	25.4	25.9	25.6	24.8	26.2	16 - 17◦C
Conductivity µs/cm (Mg/l)	196.5	235	235	134.5	155	159.5	525	170	-
Total dissolved solid (Mg/l)	97.8	117	117	67.7	76	80.7	262	85	1000 Mg/l
Sulphate (Mg/l)	15	4	6	7	3	3	2	8	250 Mg/l
Calcium hardness $Ca^{2}+$ (Mg/l)	28	34	35	25	28	33	56	28	-
Magnesium hardness $Mg^{2}+$ (Mg/l)	12	11	15	20	12	22	24	20	-
Nitrate N (Mg/l)	0.00	0.001	0.000	0.002	0.002	0.004	0.000	0.002	0.00 Mg/l
Colour Hz (Mg/l)	10	5	10	10	11	5	15	5	0 -15 Mg/l
Turbidity NTU (Mg/l)	7	2	6	7	5	1	9	2	5 Mg/l
Total hardness (Mg/l)	40	45	50	45	40	55	80	45	500 Mg/l

2.4.1. PH

Provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral and greater than 7 is more basic and less than 7 is more acidic). Figure 3.4 shows a graphical representation of the pH levels in eight sampled wells.

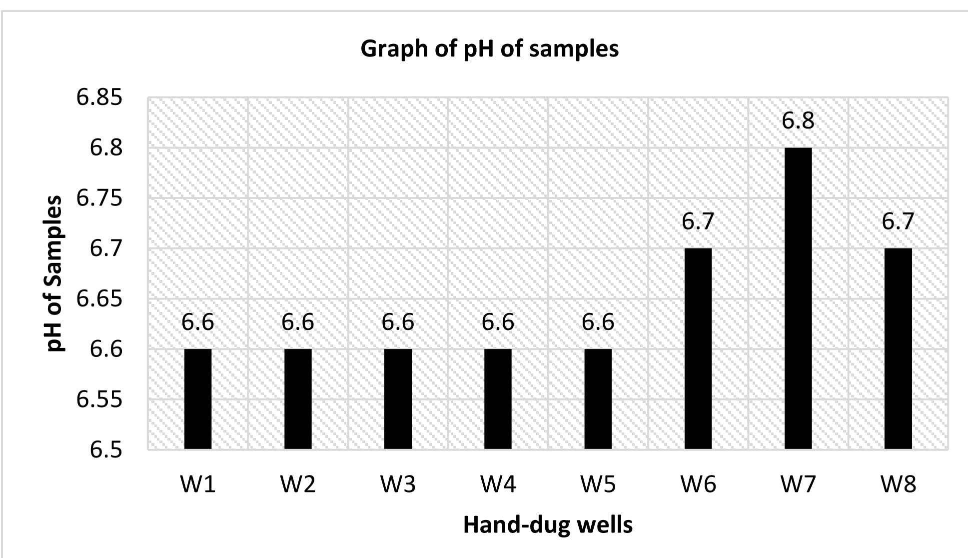

Fig. Error! No text of specified style in document..**6.** The pH Levels of Samples of Hand-dug wells.

According to the World Health Organization's (WHO) and the Ghana standards for quality water (GSB, 2009), the average PH required for quality water should be 6.5 – 8.5. A PH level more than 9.0 is very much unusual and could indicate contamination. From the figure 3.4 above, almost all the eight wells have PH levels within the WHO approved limit. The PH levels are tolerable which also indicate that, the level of contamination in these wells are very minimal.

2.4.2. Temperature

The temperature for the wells sampled ranged between 24.8oC – 26.6oC. According to the Ghana Standards for water (GSB, 2009), the temperature of water for consumption should be between 27oC – 28oC. This implies that the samples were within tolerable temperature limit

2.4.3. Conductivity

Conductivity indicates ionic presence (charge) in the water. The Ghana standard for conductivity of drinking water is 1000.0 µS/cm (GSB, 2009). Figure 3.5 presents the graph of hand-dug wells against their conductivities.

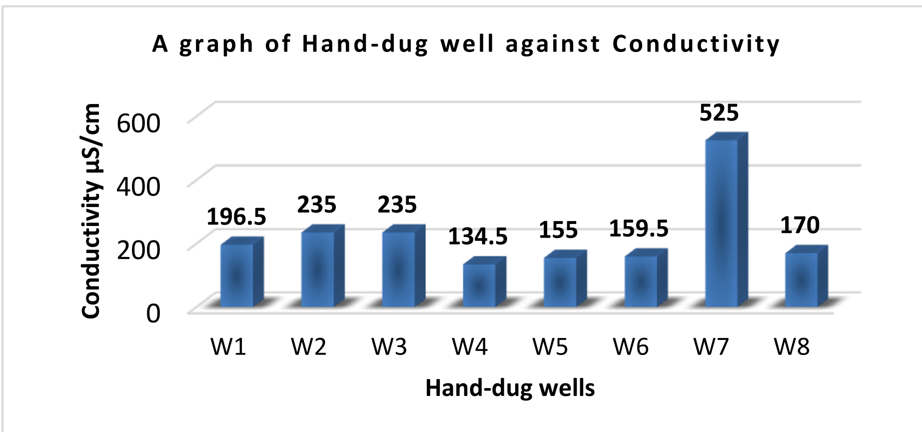

Fig. Error! No text of specified style in document..**7.** Conductivity of Samples.

From figure 3.5, the average conductivity of the sampled hand-dug wells were between 134 and 525 µS/cm. This implies that the samples were within the Ghana standards (GSB, 2009). It can be deduced from figure 3.5 above that W7 had the highest conductivity and it seems to be an outlier. This is because, that wells were exposed to the atmosphere (i.e. no cover), so rainwater which has some level of conductivity, falls directly into it without any filtration processes thereby increasing it Conductivity levels.

2.4.4. Total dissolved solids

The Total Dissolved Solids (TDS) is a measure of the quality of soluble matter (i.e. solids) that makes up the water. The recommended WHO standard is 1000Mg/l (1000 Milligram per litre). From the table 3.5 above, the TDS for all the wells fall within the acceptable value recommended by the WHO. Therefore none of these wells has TDS above the normal standard.

2.4.5. Sulphates

The WHO recommended value for Sulphate ($SO4^{-2}$) in portable drinking water is 250Mg/l. Concentration of Sulphate (>400Mg/l) in combination with magnesium introduces a bitter taste in water. Higher concentration of Sulphate (> 1000 Mg/l) has a laxative effects and also high concentration of Sulphate in combination with calcium form adherent heat retarding scales.

All the wells had their Sulphate levels below the WHO standard of 250 Mg/l. In effect, that has accounted for the non-bitter taste of the water in each of the wells. The amount of Sulphate is not enough to combine with the calcium content to form adherent, heat retarding scales. Therefore, the Sulphate amounts in all the wells are within the tolerable limits.

2.4.6. Calcium (Ca^2+)

WHO has no recommended value of Calcium content in portable water, but the European Commission has a recommended value of 100 Mg/l. Calcium (Ca^2+) is not of health relevance under concentrations common for ground and fresh surface water. But the more Calcium (Ca^2+) the more soap required (hard water).

2.4.7. Magnesium (Mg^2+)

Like Calcium, Magnesium (Mg^2+) is not of health relevance under concentrations. However, the more Magnesium (Mg^2+), the soap required (hardness of water). The WHO and European Commission has not specified value as specific requirement of Magnesium (Mg^2+) in water. Judging from the figure 3.6 below, all the wells has Magnesium content value between 11 – 24 Mg/l.

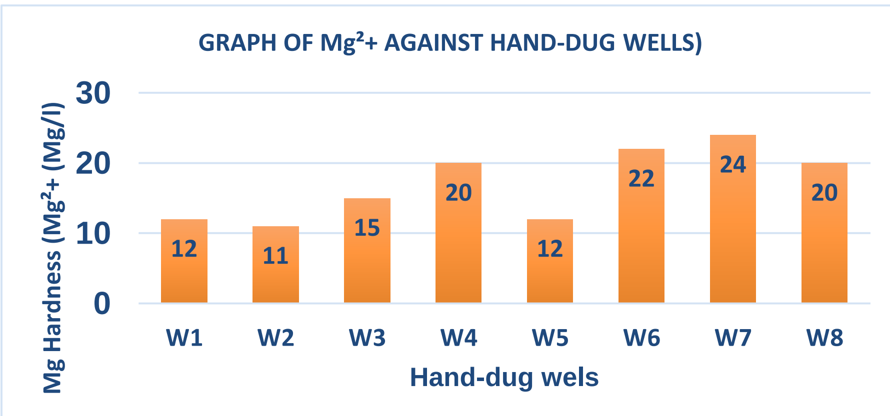

Fig. Error! No text of specified style in document..**8.** Magnesium content of Hand-dug wells

2.4.8. Turbidity

The WHO standard for Turbidity is 5 NTU. From figure 3.7 below, four hand-dug wells (W1, W3, W4, and W7), had their Turbidity content above the WHO standard. This is indicative of the fact that these wells are engulfed with suspended mater. Thus requires that the water in these wells needs to undergo filtration processes to reduce drastically their levels of Turbidity. But the Turbidity levels in the wells W2, W5, W6 and W8 are all within the recommended levels.

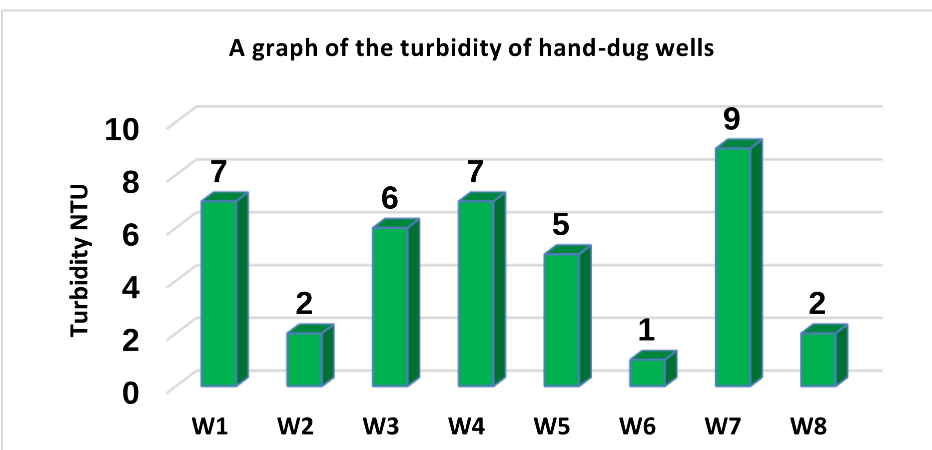

Fig. Error! No text of specified style in document..**9.** Turbidity of Hand-dug wells

2.5. Bacteriological Results

Bacteriological analysis conducted on the samples considered E. coli, faecal coliforms and total coliforms. The results are shown in table 3.6 below:

Table Error! No text of specified style in document.**.5**
Bacteriological Analysis results

Sample	Total coliform	Faecal coliform	*E. COLI*	WHO limits
W 1	19	6	Absent	0.00
W 2	68	22	Absent	0.00
W 3	21	9	Absent	0.00
W 4	121	39	Absent	0.00
W 5	3	0	Absent	0.00
W 6	29	10	Absent	0.00
W 7	152	42	Absent	0.00
W 8	53	19	Absent	0.00

Despite the fact that all water quality standards do not permit the presence of pathogens and coliforms, all the samples showed the presence of one form of coliform or the other.

2.6. Hand-dug well Treatment procedures

The approach for tackling hand-dug well pollutions depends on a variety of factors, which are often interrelated. These approaches are influenced, to some degree at least, by whether the well is privately owned or is a public supply well. The following list of approaches can be used:

An assessment of the vulnerable or groundwater pollution prone areas and well demarcated.
Proper siting of wells and hazards zones;
Monitoring of well water quality;
Assessments of water quality data;
Well construction and sanitary protection against potential pollutants;
Disinfection and Public awareness

3. Conclusion

It was concluded from the results and discussions above that

All the samples have one form of coliform or the other. The presence of the coliforms makes the hand-dug wells unsafe for usage especially drinking without prior treatment.

The samples had good physic-chemical parameters. The samples were within the allowable limits of WHO and the Ghana water standards.

Due to the location of some of the wells and the presence of coliforms, it is necessary for water from the wells to be treated.

Based on the research and conclusions drawn, the following recommendations can help improve the quality of water from hand-dug wells

It also recommended that, all the water from wells in the enclave after they have gone through filtration, should be disinfected with chlorine.

The Ghana Health Service and allied Environmental Agencies should visit the various enclaves to monitor the water qualities.

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