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Comparative Analysis Of The Tensile Strength Of Bamboo And Reinforcement Steel Bars

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Abstract— This study aims at testing and comparing the tensile strength of bamboo and steel reinforcement bars as structural material for building construction. Tensile strength tests were carried out on various sizes steel and bamboo; categories of reinforcement bars such as; 10mm, 12mm, 16mm, 20mm and 25mm of both high-yield and mild-yield steel reinforcement bars were both tested along with same sizes of bamboo with 10mm cross-sectional thickness. Results are presented in tables and graphs and show that the tensile strength of high-yield steel bars outstrips that of mild-yield and bamboo respectively. The study finds that the breaking force (FB) for 10mm (HY) = 24.42KN; tensile strength = 457.13N/mm2; yield stress = 379.02 N/mm2 and breaking elongation = 39.67mm respectively. For 12mm (HY), breaking force (FB) = 52.14 KN; tensile strength = 689.12 N/mm2; yield stress = 551.30N/mm2 and breaking elongation = 36.58mm. 16mm (HY) results in breaking force (FB) = 126.67KN; tensile strength = 771.61N/mm2; yield stress = 494.10N/mm2 and breaking elongation = 70.87mm. The same factors for 20mm yields, breaking force (FB) = 163.97KN; tensile strength = 713.40N/mm2; yield stress = 614.74N/mm2 and breaking elongation = 61.57mm. While the 25mm (HY) produces, breaking force (FB) = 306.17KN; tensile strength = 792.90N/mm2; yield stress = 678.46N/mm2 and breaking elongation = 52.36mm respectively. Mild Steel (MY) 10mm yields, breaking force (FB) = 14.76KN; tensile strength = 290.49N/mm2; yield stress = 233.17N/mm2; and breaking elongation = 78.86mm. 12mm (MY) results in breaking force = 40.35KN; tensile strength = 508.08N/mm2; yield stress = 376.17N/mm2 and breaking elongation = 84.10mm. 16mm (MY) yields, breaking force (FB) = 79.72KN; tensile strength = 508.71N/mm2; yield stress = 349.10N/mm2 and breaking elongation = 111.39mm respectively. For 20mm mild steel, breaking force (FB) = 83.04KN; tensile strength = 372.98N/mm2; yield stress = 284.64N/mm2 and breaking elongation = 47.40mm. While the 25mm (MY) steel bar results show, breaking force (FB) = 163.04KN; tensile strength = 701.74N/mm2; yield stress = 599.77N/mm2 and breaking elongation = 56.84mm. On the other hand, bamboo yields for the same size width and constant thickness of 10mm, the 10mm-25mm bamboo sizes result as; 10mm (bamboo); breaking force (FB) = -2.1KN; tensile strength = 31.55N/mm2; yield stress = 0.00N/mm2 and breaking elongation = 0.00mm. 12mm width with 10mm thickness yields, breaking force (FB) = -1.28KN; tensile strength = 31.07N/mm2; yield stress = 0.00N/mm2; and breaking elongation = 0.00mm. 16mm (bamboo), breaking force = 1.85KN; tensile strength = 68.82N/mm2; yield stress = 49.45N/mm2 and breaking elongation = 30.40mm. For the 20mm width size bamboo with same 10mm thickness, breaking force (FB) = -0.12KN; tensile strength = 62.66N/mm2; yield stress = 50.23N/mm2 and breaking elongation = 18.20mm respectively. Finally, the 25mm (bamboo) size gives, breaking force (FB) = 4.76KN; tensile strength = 94.60N/mm2; yield stress = 50.19N/mm2 and breaking elongation = 21.11mm. The study concludes that due to the minimal breaking force (FB) of bamboo, it cannot be employed as a main structural member in building and other engineering works but can be used as portioning wall, ceiling, roof and other areas of engineering construction that is not heavy load-bearing.

Keywords: ***Tensile, Strength, Bamboo, Reinforcement Steel Bars***

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I. INTRODUCTION

SAFE drinking water is one of the major prerequisites for a healthy life, but waterborne disease is still a major cause of death in many parts of the world, particularly in children, and it is also a significant economic constraint in many subsistence economies [1].Drinking water is derived from three basic sources: surface waters, such as rivers and reservoirs, groundwater, and rainwater [1]. Water contains natural contaminants, particularly inorganic contaminants that arise from the geological strata through which the water flows and, to a varying extent, anthropogenic pollution by chemicals. There are a number of possible sources of man-made contaminants, some of which are more important than others. These fall into the categories of point and diffuse sources. Discharges from industrial premises and sewage treatment works are point sources and as such are more readily identifiable and controlled; run off from agricultural land and from hard surfaces, such as roads, are not so obvious, or easily controlled. Such sources can give rise to significant variations in the contaminant load over time [1]. There is also the possibility of spills of chemicals from industry and agriculture and slurries from intensive farm units. Many species give rise to nuisance chemicals that can cause taste and odour and interfere with drinking water treatment. However, they frequently produce toxins, which are of concern for health, particularly if there is only limited treatment [1]. Quality drinking water is essential for life and it is important to realize that the basic right of every human being is to have access to clean water and sanitation at an affordable price. Unfortunately in many countries around the world, including Ghana, water has become a scarce commodity as only a small proportion of the populace have access to treated water [2]. Alternative sources of water such as rainwater, ground water, and surface water have become major sources of drinking water for people living in new settlements and some residents who do not have access to treated water in Ghana [2]. The quality of drinking water is important because they have direct effects on the health of individuals [2]. Safe drinking water is one of the major prerequisites for a healthy life, but water-related disease is still a major cause of death in many parts of the world, particularly in children, and it is also a significant economic constraint in many subsistence

economies [1]. Drinking water is derived from three basic sources: surface waters, such as rivers and reservoirs, groundwater, and rainwater [1]. A hand-dug well is an excavation or structure created in the ground by digging, boring, or drilling to access groundwater in underground aquifers [11]. It provides a cheap and low-tech solution to accessing groundwater in rural location in developing countries, and may be built with high degree of community participation [11]. Hand-dug well water typically contains minerals in solution than surface water and may require treatment to soften the water [11]. As hand-dug well water may be contaminated due to minerals, such as chloride, fluoride, magnesium, calcium, nitrate, etc. underground; it is often not considered suitable for drinking without treatment [12]. There are many sources of chemical contaminants in drinking water. Hand-dug well water often comes from an aquifer or groundwater, and can be easily deepened, if the ground water level drops, by telescoping the lining further down into the aquifer [11]. A qanat is an ancient water collection system made up of a series of wells that linked underground water channels and collects flowing water from a source usually a distance away, stores it, and then brings the water to the surface using gravity. Much of the population of Iran and other arid countries in Asia and North Africa historically depended upon water from qanats [13]. However, naturally occurring chemicals that are usually found in groundwater become contaminants in wells from a health standpoint [1].

1.2 Sources of contaminations in drinking water

Well water has become one of the most alternative sources of water for several people but its quality is most often doubtful due to presence of minerals in solution, especially in shallow wells that are susceptible to contamination by point and non- point sources of pollutants. Some of these pollutants are trace elements and pesticide residues that contaminate hand-dug wells, thereby rendering them unfit for consumption. Many households, vegetable farmers and food vendors rely on this water source for drinking, preparation of food, irrigation, and other commercial purposes. Begoro, in the Fanteakwa District, has a lot of challenges with water supply and therefore there is heavy reliance on water in hand-dug wells which are shallow in nature. Studies indicate that, aquifers are susceptible to

contamination from natural or man-made sources. As a result, wells should not be placed where known contaminations exist, and wells should be tested to confirm whether safe drinking water is being provided [3]. However, it is not known whether chemical parameters and their concentrations in hand-dug wells in Begoro meet Ghana Standard Authority standards, and whether the chemical water quality of pipe borne water differs from hand-dug wells in Begoro. The study assesses the chemical drinking water quality of pipe borne water and hand dug wells in Begoro community. US-Centre for Disease Control and Safety [4], stated in their report that, although the United States has one of the safest drinking water supplies in the world, sources of drinking water can still become contaminated through naturally occurring chemicals and minerals such as arsenic, radon, and chloride. Other sources include local land use practices that introduce pesticides, chemicals, and animal feeding operations, malfunctioning wastewater treatment systems and sewer overflows. Contamination of a private well can impact not only the household served by the well, but also nearby households using the same aquifer. An epidemiological study carried out in Tambov revealed that hard water with over 400-500 mg/l of $CaCO_3$ was possible cause of high incidence of diseases including cancer [5]. Increases in water hardness may worsen sensorial characteristics of drinking water or drinks and meals prepared with such water. For instance, formation of a layer on the surface of coffee or tea, loss of aromatic substances from meals and drinks due to bonding to calcium carbonate, unpleasant taste of water itself for some consumers can make consumers sensitive [5]. The suspected chemical contaminants in hand-dug wells are not recorded. This paper seeks to analyze specific chemical water quality parameters and compare their levels in water from hand-dug wells and pipe-borne water with national and international standards.

1.3 The need for Water quality studies in hand-dug wells in rural areas

Water quality studies in hand-dug wells will help in assessing the chemical quality of water as compared to Ghana Standard Authority standards. In Begoro community, knowledge on the chemical quality of hand-dug wells will help in assessing the possible health effects of chemical contaminants in hand-dug wells so as to establish the chemical water quality differences between the hand-dug wells and pipe borne water. Such studies are useful in informing policy interventions on the intensification of education and implementation of regulations on safe drinking water by the Ghana Standards Board, the Ghana-Environmental Protection Agency (EPA), the District Environmental Health Units and Ghana Urban Water Company. This will go a long way to reduce incidences of water pollution and the associated water related diseases. This is because, chemical particles in hand-dug wells as a result of contamination and pollution from organic and inorganic ions underground, could cause heart infections, kidney problems, fluorosis, methaemoglobinaemia, and other water related diseases [9]. It is suspected that water from wells in unhygienic areas could be contaminated due 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 overutilization of limited water resources [14]. Contaminants are regulated when they occur in drinking water

supplies and are expected to threaten public health [3], [15]. Authors explain that most levels of contamination that are established by the EPA allow sufficient margin of safety, but acceptable contaminant levels vary widely among individuals and population groups. For example, high sodium levels, harmless for most people can be dangerous for the elderly, people with high blood pressure, pregnant women, and people having difficulty in excreting sodium. However, [15] do not consider the levels of chemical contaminants in drinking water high enough to cause acute or immediate health effects. Examples of acute health effects are nausea, lung irritation, skin rash, vomiting, dizziness, and even death. The authors expect contaminants to more likely cause chronic health effects - effects that occur long after repeated exposure to small amounts of a chemical. Examples of chronic health effects include cancer, liver and kidney damage, disorders of the nervous system, damage to the immune system, and birth defects. Fabrizi [5] found that in areas supplied with drinking water harder than 500 mg/l $CaCO_3$, there were high incidence of gallbladder disease, urinary stones, arthritis and atrophies as compared with those supplied with soft water. Contamination can also take place in consumers‟ premises from materials used in plumbing, such as lead or copper, or from the back-flow of liquids into the distribution system as a consequence of improper connections. Such contaminants can be either chemical or microbiological. People who drink water containing radionuclide, such as alpha emitters, beta emitters, radon, and combined radium (226/228), in excess of EPA's standard over many years may have an increased risk of getting cancer [8]. It has been demonstrated that consuming water of low mineral content has negative effect on homeostasis mechanisms [16].

1.4 Concentrations of chlorides

Chlorides are widely distributed in nature as salts of sodium, calcium, and potassium. Chloride concentration in excess of

250mg/l or (250ppm) gives rise to taste in water [6]. According to the WHO, chloride in groundwater are from both natural and anthropogenic sources such as run-off containing road de- icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas [7]. The US-EPA set an enforceable regulation for vinyl chloride called, maximum contaminant level (MCL) at 0.002mg/L or

2ppb. So, when contaminant level of vinyl chloride in water sample exceeds this amount, the water is said to be lethal to health. This is because people who drink water containing vinyl chloride in excess of the maximum contaminant level

(MCL) for many years have increased risk of cancer. Contamination of vinyl chloride occurs through leachates from polyvinyl chloride (PVC) pipes, discharged from plastic industries, sewage treatment plants, etc. US-EPA (2013) describes sodium and chloride in drinking water as „salt‟ since many people use the word „salt‟ for sodium or sodium chloride. When salt such as sodium chloride dissolves in water, it breaks into positively and negatively charged ions. Sodium chloride breaks up into sodium and chloride ions in water. The US-EPA [8] reissued a list known as the Drinking Water Contaminant Candidate List (DWCCL) in which sodium and chloride were included. The EPA identifies 250mg/L as a concentration at which chloride is expected to cause a salty taste in drinking water. Water users typically notice the presence of high chloride before an equal amount of sodium.

Chlorides are costly to remove from water. Effective treatments include, Reverse Osmosis (RO), Distillation, and De-ionization. Distillation is more costly to operate and is only feasible to a few gallons of water a day. It is not effective for organic contaminants. Whiles De-ionization is an effective method of water treatment, the chemicals are dangerous and inappropriate in a residence. This method has similarities to a water softener, but uses strong acids and bases rather than salt to regenerate the system. The US-EPA [9] view on chloride concentration in water is that, substantial levels of chloride imply contamination by human activities, including road salt storage, discharge from water softeners, human or animal waste, and leachates from landfills. It is known that, chloride concentration of well water exceeds that of sodium approximately 50% due to differences in atomic weights. Hence, judgments on concentrations of salts in should be made only after reviewing several samples that have been taken at difference times of the year. Effects of chlorides in water are explained by the presence of elevated chloride, and are initially considered as indication of increased risk of more serious chemical pollution. The elevated levels of chloride somewhat increase the ionic conductance of water, and thus increase the potential for corrosive damage to plumbing fixtures by water. International Organization for Standardization (IOS) [10] indicates that, sodium chloride (NaCl2) is widely used in the production of industrial chemicals, such as, caustic soda, chlorine, sodium chlorite, and sodium hypochlorite. Potassium chloride is used in the production of fertilizers. Hence, when a well is constructed near a farm it can be polluted by the farm through leachates. According to International Program on Chemical Safety [18] vinyl chloride is a narcotic agent that can cause loss of

consciousness at 25g/m3. The explanation is that, that concentration of vinyl chloride above 2g/m3, over periods ranging from one month to several years have been reported

to cause specific pathological syndrome found in people who get in contact with vinyl chloride. According to the [17], vinyl chloride has relatively low solubility in water and low capacity to be absorbed on particulate matter and sediment. When released to the ground, vinyl chloride is not absorbed on the soil but migrates readily to groundwater, where it may be degraded to carbon dioxide and chloride ion or remain unchanged for several months, or even years. Vinyl chloride has been reported in groundwater as a degradation product of chlorinated solvents such as trichloroethene and

tetrachloroethene [17]. Clinical findings include scleroderma of connective tissues in fingers, with dermal thickening and subsequent bony changes in the tips of fingers called

acroosteolysis; peripheral circulatory changes with the classical picture of Reynaud disease; enlargement of the spleen and liver, with specific histological appearance and respiratory manifestation. Hence, the presence of chemical contaminants in water can lead to health issues, including gastrointestinal illness, reproductive problems, and neurological disorders. Infants, young children, pregnant women, the elderly, and people whose immune systems are compromised because of HIV/AIDS, chemotherapy, or transplant medications, may be especially susceptible to illness from some contaminants [4].

1.5 Concentration of fluorides

Fluoride is present in water and higher concentrations are usually associated with ground water. Skeletal fluorosis has been evidenced in persons when water contains more than 3.60 mg/l of fluoride [9]. Waterborne fluoride is a major cause of morbidity in parts of the world, including the Indian sub- continent, Africa and the Far East, where concentrations of fluoride can exceed 10 mg/l [1]. High intakes of fluoride can give rise to dental fluorosis, an unsightly brown mottling of teeth, but higher intakes result in skeletal fluorosis, a condition arising from increasing bone density and which can eventually lead to fractures and crippling skeletal deformity [1]. A WHO working group concluded that skeletal fluorosis and increased risk of bone fractures occur at a total intake of 14 mg fluoride per day, and there is evidence suggestive of an increased risk of bone effects at intakes above about 6 mg fluoride per day [1]. Public Health Engineering Department in West Bengal (2006) reports that, India is among 23 Nations where health problems occur due to consumption of fluoride contaminated water because, skeletal fluorosis has been evidenced in persons when water containing more than 3.60 mg/l of fluoride were consumed depending on intake from other sources.

1.6 Concentration of nitrates and nitrites

Contaminants such as heavy metals, nitrates and salt have the potential of polluting water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over-use of limited water resources [2]. The maximum contaminant level (MCL) for nitrate in drinking water is 10 milligrams per liter (mg/l), often expressed as 10 parts per million (ppm) - measured on the basis of the nitrogen content of nitrate [19]. According to [7], "high concentrations of nitrate and nitrite ions may give rise to potential health risks such as methmoglobinemia or „blue- baby-syndrome" particularly in pregnant women and bottle-fed infants respectively, nitrate at elevated concentrations is also known to result in cyanosis in infants". Infants have higher intake of water for weight than adults. Consequently, infants ingest relatively higher amounts of nitrate. WHO [19] reports that, high levels of nitrate from fertilizer or wastewater can present a serious health risk to infants, and poisons resulting from improper use or disposal of chemicals can cause long- term and chronic health problems for humans or animals. Some adults may be susceptible to the development of nitrite induced methmoglobinemia. These include pregnant women with a particular enzyme deficiency, adults with reduced stomach acidity, and those with a deficiency in the enzyme needed to change methemoglobin back to normal hemoglobin, a condition which can be hereditary [20].

Another concern about nitrate ingestion is the possibility that nitrites in the stomach and intestines may contribute to the development of some cancers. Nitrate in groundwater is of concern not only because of its toxic potential, but also because it may indicate contamination of the groundwater. For instance, a source of contamination due to animal waste or effluent from septic tanks, bacteria, viruses, and protozoa may be indicated by the presence of nitrates [21]. Contamination of groundwater by fertilizers may also indicate the presence of other agricultural chemicals such as pesticides. The source of nitrate may be a clue to other contaminants that may be present [1]. Studies indicate rapid and widespread distribution of vinyl chloride. Rapid metabolism and excretion limit the accumulation of vinyl chloride in the body. The highest concentrations of metabolites are found in the kidney, liver, spleen, etc., [18].

1.7 General quality requirement for drinking water

Color in water may be caused by the presence of minerals such as iron and manganese or by substances of vegetable origin such as algae and weeds [21]. Color tests can indicate the efficacy of the water treatment system [21]. Turbidity in water is caused by suspended solids and colloidal matter. This may be due to eroded soil caused by dredging or due to growth of micro-organisms. High turbidity makes filtration expensive. If sewage solids are present, pathogens may be encased in particles and may escape action of chlorine during disinfection [17]. In the case of drinking and other domestic usage of water, it should be potable and palatable. Potable in the sense that the water must be safe for human consumption without harmful organic or inorganic compounds, that could cause adverse physiological effects. For water to be palatable, that water must be free from turbidity, color, odor and objectionable taste [1]. However, the potable water supply appears inadequate and most of people depend on hand-dug wells, streams, and rainwater for water supply. For instance, only 30% of the people living in Begoro have access to infrequent supply of pipe borne water [21]. Begoro is one community in Fanteakwa District that lies in the middle of Eastern region as one of the oldest settlements with a population of about 23,569 [21]. Fanteakwa is one of the Districts in Ghana that are well endowed with natural resources. The paper assesses the chemical water quality parameters in water from hand-dug wells and pipe-borne water and compares the levels with national and international standards.

II. METHODOLOGY

Laboratory analysis was conducted to find the quality of water in hand-dug wells and pipe borne water in the Begoro community. Water samples were collected from five (5) hand- dug wells in the community and pipe borne at six sampling sites. The choice of hand-dug wells in the community was influenced by lateral distance from agricultural and sanitary sites, such as pit latrines, refuse dumps, farms, etc. that may predispose them to chemical contaminations from pesticide residues and other forms of organic wastes. Water samples were collected using sterilized sampler into thoroughly cleansed and well treated 1.5litres plastic bottles. At the site of sampling, the bottles were rinsed again with the samples water. Sampling was done by hand with the bottle held near the base with one hand, the cap removed and the bottle plunged downward into the water. The bottle was tilted slightly upward to displace the air and then pushed forward away from the hand to avoid contamination. Sample containers were sterilized and labeled as and when a sample is collected. To minimize bio-degradation between sampling and analysis, samples were immediately preserved in ice chest containing ice packs without freezing. This was done to minimize changes in content and maintain samples since travelling with the samples from study area to the laboratory was considered too long journey.

2.1 Equipment and Glassware

The following equipment and glassware were used: Hach DR/200 Spectrophotometer, analytical balance, incubator, autoclave, 250ml conical flask, beaker, burette, pipette, dropper, wash bottle, measuring cylinder, sterile sample bottles, culture tubes containing inverted Durham vials, paper, cello tape.

2.2 Procedure

Two sample cells were used for each analysis. One sample cell was filled with measured quantity of prepared sample and the other cell was filled with de-ionized water to serve as blank. The sample cell with its contents were placed in the Hach DR/200 Spectrophotometer and analyzed. The test was repeated for the samples depending on the quality parameter under investigation. In the argentometric titration, the water samples were filtered through a clean Whitman filter paper, and about 100ml discarded initially and the remaining kept in a beaker. 20ml of the filtered water samples was pipette into a conical flask and acidified with 5ml 6MHNO3. 0.01M AgNO3 was added to the water sample from the burette to give 5mL excess. This was done by adding 5mL of AgNO3 when turbidity of the mixture persists. 2ml of pure nitrobenzene was added followed by 1ml ferric alum indicator. The solution was gently swirled till the chlorides precipitated. The excess AgNO3 was titrated with 0.1M NH4SCN till a permanent faint brown coloration appeared. The titration was repeated three (3) times to obtain average values. Spectrometric, colorimetric, and titration with EDTA methods were used for fluoride, nitrate, and hardness, respectively.

III. RESULTS AND DISCUSSIONS

Chemical parameters are very important in water quality analysis for hand dug wells used for drinking and other purposes. Most of the chemical parameters are known to have health effects on users whiles others are not. Due to this, the Guidelines for Drinking Water [22] and Ghana Standard Authority guidelines were used in discussing and comparing the results obtained. The overall suitability of water from hand dug wells for drinking purpose were compared to the pipe borne water quality based on the similar tests. The results are discussed under; (a) the chemical quality of water in hand-dug wells compared to Ghana Standard Authority standards in Begoro, (b) possible health effects of chemical contaminants in hand-dug wells, (c) chemical quality of hand-dug wells whether it meets the Ghana Standard Authority standards, and (d) chemical water quality differences between the hand-dug wells and pipe borne water in Begoro community.

3.1 Comparing chemical quality of water in hand-dug wells in Begoro with Ghana Standards Authority guidelines

From table 1, the chemical quality of hand-dug wells were within the guideline limits of Ghana Standards Authority, comparatively. The values were below the guideline values. Whiles chloride values in the hand-dug wells ranged between, 200.6 mg/l to 210.5 mg/l, the Ghana standard Authority maximum value for chloride was 250.0 mg/l. Fluoride concentration in hand-dug wells ranged from 0.50mg/l to 0.90mg/l, compared to GSA‟s standard of 1.50mg/l. This means that when we compare the values in the hand dug wells to the national guidelines, the one from the hand-dug wells were lesser than the maximum considered value. Nitrate concentration in the hand-dug wells was within the guideline values of GSA. The result ranges from 10.5mg/l to 16.0mg/l; whiles the GSA value is 50mg/l. The same observation or conclusion can be made for total hardness which value was between 51.0 and 89.5mg/l and Ghana Standard Authority guideline value was 350.0mg/l. The Ghana Standards Authority (GSA) standard for chloride is 250mg/l, whiles chloride in hand-dug wells in Begoro is lower than the

3.2 Possible health effects of the chemical contaminants in hand-dug wells.

Chloride ions are non-cumulative toxins, an excessive amount of which, if taken over a period of time, can constitute a health hazard indicated by [23]. As observed in the Table 1, chloride

Pipe Borne

GSA Standards

200.6	0.50	7.3	50.0
250	1.5	50.0	350.0

level in hand-dug wells and pipe borne water were generally low, implying that there may not be any health effects by drinking water from both the hand-dug wells and the pipe borne water. Chloride concentration in excess of 250mg/l or (250ppm) gives rise to taste in water as indicated by [6]. Hand dug wells were characterized by low fluoride ion concentrations (0.50 to 0.95), and fell within WHO and Ghana Urban Water Company (GUWC) acceptable limits of drinking and potable water (1.5 mg/l). The fluoride level in the hand dug wells were also low (0.50 to 0.90mg/l), indicating that there will not be any health hazards associated with consuming of water containing fluoride. Fluoride in pipe borne water (0.50mg/l) was below the GSA guideline levels. Fluoride is expected to be present in water and higher concentrations are usually associated with ground water. Skeletal fluorosis has been evidenced in persons when water contains more than 3.60 mg/l of fluoride as observed by [9] report. Hardness is a natural characteristic of water which can enhance its palatability and consumer acceptability for drinking purposes. Health studies in several countries in recent years indicate that mortality rates from heart diseases are lower in areas with hard water indicated by [8]. Undesirable effects due to the presence of calcium and magnesium in drinking water may result in rendering water hard. Hand dug wells and pipe borne water in Begoro are characterized by moderately low (51.0-

89.0mg/l; 50.0mg/l) calcium carbonate ($CaCO_3$) ion concentrations and are within WHO/GSA maximum acceptable limits for drinking and potable water (350 mg/l). Hence, the water is soft. In areas supplied with drinking water harder than

500 mg/l $CaCO_3$, higher incidence of gallbladder disease, urinary stones, arthritis and atrophies as compared with those supplied with soft water are reported by [5]. Low total hardness of water indicates that health problems may not be associated with the drinking water.

WHO standards 250	1.5	50.0	350.0

Source: Laboratory Tests, 2015

3.3 Comparing chemical quality of hand-dug wells with

(GSA) standards

In Figure 1, hand-dug wells with an average value of 13.1mg/l nitrate ion concentration are shown. This means that nitrate concentration in the hand dug wells is lower than [22] edition of water quality standards, whose recommended value is 50mg/l nitrite for drinking water. This shows that, water in hand-dug wells in Begoro is safe for drinking. High values of nitrate in Figure 1, can result in algal growth and phytoplankton causing eutrophication which may adversely affect the quality of the water [22]. High nitrate levels in water for drinking are hazardous to infants since this can induce the "blue baby" syndrome or methaemoglobinaemia [22]. The syndrome also affects pregnant women with particular enzyme deficiency, adults with reduced stomach acidity, and those with deficiency in the enzyme needed to change methemoglobin back to normal hemoglobin, a condition which can be hereditary. The nitrate itself is not a direct toxicant but a health hazard if it is converted to nitrite which reacts with blood haemoglobin to cause methaemoglobinaemia [8]. Hence, comparatively, water quality values obtained in Begoro indicate that health hazards may not be associated with drinking water from hand-dug wells and pipe borne water sources in relation to nitrate concentration.

IV. CONCLUSION

This study shows that, water in hand dug wells in Begoro are of good chemical quality and safe for drinking. Chloride, fluoride, nitrates and hardness averaged 210.5mg/l, 0.90mg/l, 38.0mg/l, and 89.0mg/l respectively, indicating that hand dug wells are good because they are within the limits of set guidelines. Pipe borne water showed concentrations of chloride (200.6mg/l), fluoride (0.50mg/l), nitrate (7.3mg/l), and total hardness (50.0mg/l), indicating that, pipe borne water in the Begoro community is also good for drinking. Begoro community has safe drinking water because chemical parameters in water used by the inhabitants meet both national and international guidelines for safe drinking water. However, water samples used in this study were collected during the dry season for analysis; so, it is recommended that similar tests on water in the hand-dug wells and pipe borne water should be carried out in the rainy and wet seasons to ascertain seasonal variations in the water quality parameters.

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