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Assessment of the quality of water from hand dug wells at Dutsin Tanshi Bauchi, Bauchi State, Nigeria

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Abstract
This study focused upon the determination of physicochemical and microbial properties, including metals, selected anions and coliform bacteria in drinking water samples from Hand-dug wells in Dutsin Tanshi Bauchi Local Government Area of Bauchi State, Nigeria. Water samples collected from sixteen (16) different wells at Strategic positions and determined to ascertain how safe the water is for human consumption without treatment. Twenty one (21) relevant parameters on the test of water quality were taken into consideration. The physical and Chemical parameters assessed include temperature, conductivity, and total dissolved solid (T.D.S.). turbidity, pH, color, Total hardness, total alkalinity, calcium, magnesium potassium, sodium, copper, chromium, manganese, nitrate, sulphate, chloride and bicarbonate, while microbial parameters include total coliform and faecal coliform. The data showed variation the investigated parameters in samples as follows: Temperature 26.11-26 ºC, Conductivity 40-2670us/cm, T.D.S. 200-1340mg/L, Turbidity 0.3-9.69 NTU, pH 6.7-7.9, Colour 1-71, Total Hardness as $CaCO_3$ 155-385 mg/L, Total Alkalinity as $CaCO_3$ 20-163mg/L, Ca^{2+} 32-128mg/L, K^+ 1.3-88mg/L, Mg^{2+}4.88-48.63mg/L, Na^+17.68-173.85mg/L, Cu^{2+}0.01-0.95mg/L, Cr^{3+}0.00-0.05mg/L, Zn^{2+} 0-0.04 $NO3^{2-}$14.72-225.28mg/L, SO_4^{2-}5-96mg/L, Cl^-23.04-236.8mg/L, HCO_3^-24.4-201.3mg/L, Total coliform 0.0-890 cfu/100ml, Faecal coliforms 0.0-366cfu/100ml. The results revealed high variation between the WHO, NIS and NAFDAC standards for portable water and the obtained values. The implication is that water from most wells in the study area is not suitable for direct human consumption. The closeness of wells to refuse dumpsite was blamed for increased levels of concentration of pollutants. To avoid further pollution of ground water, the study therefore recommends that the site for wells should be at least 30m away from the source of contamination especially refuse dumpsite, the surrounding environment should be kept clean and tidy to avoid or reduce contaminations, disinfection of wells by chlorine and continuous monitoring to determine any Change in the level of pollution at sources.

Keywords: water quality, pollutant, boreholes, hand dug wells, suitability

Introduction
Quality drinking water is essential for life [1]. Water plays an essential role in digestion, Absorption and waste elimination and safe drinking water is an internationally accepted human Right [2, 3]. Unfortunately, in several states around the country including Bauchi, water has become a scarce commodity as only a small portion populace has access to treated water. Alternative Sources of water such as rain water and ground water have become major sources of drinking Water for people living in new settlement and some resident who do not have access to treat Water in Bauchi. The provision of good quality water is needed as an urgent step that will ensure ground water quality, protection and conservation [4, 1]. Contaminated water is a global health threat placing people at risk of host of diarrhea and other illness as well as chemical intoxication [3, 5]. The world health organization (WHO) estimates that 1.8 million people die each year from Diarrhea diseases, 88% of which can be attributed to unsafe water, sanitation and hygiene [6].

Ground water has become major source of water supply for domestic, industrial and Agricultural sectors of many countries [7]. Domestic water is used for drinking, cooking, Bathing, and cleaning, however, access to safe drinking water and sanitation is critical items of Health and sustainable [8,9]. However, high population growth of Bauchi, coupled with poor development plan chronic hygienic regulations habit and inability to enforce regulations have serve collectively as recipe for environmental pollution. The quality of surface or ground Water is a function of either or both natural influences and human activities [8] the source of ground water contamination could be natural through ground water -rock interaction or through anthropogenic which involved human activities that can affect ground water quality.

Ground water pollution which is man-made is worse than natural pollution as it eventually renders water unsuitable for use than its original state [4]. Contrary to widely held theoretical views ground water being the “safe” water wells are found to be polluted interns of temperature, mineral contents, particles, solute,, organic matter and bacterial contamination. The quality of ground waters determined by testing various parameters interest on which the result is compared with the standard quantities required for water intended for human consumption and use [8]. Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have polluted water supplies as a result of in-adequate treatment and disposal of waste from humans and live stocks, industrial

discharges, and over-use of limited water resources [1].

The water used for drinking purposes should be free from toxic elements, living and non-living Organisms and excessive amount of minerals that may be harmful to health [10]. Quality and Safety of drinking of drinking water is an important public health issue [2]. Dug wells are Generally worst ground water sources interms of faecal contaminations, and bacteriological Analysis serve primarily to demonstrate the intensity of contamination and hence the level of risk To the consumer [9]. However ground water is generally a very good sources of drinking water Because of purification properties of the soil [8].

The chemical form of metal contaminant influences its solubility, mobility and toxicity in Ground water system, the chemical form of metals depend on the sources of metal waste, the soiled ground water chemistry at site [11]. Several studies such as [12, 13, 14, 15] among others Showed the relationship between ground water (well) quality and refuse dumpsite [8]. for instance [16], in his study of some physico-chemicals and bacteriological Quantities shallow well in Samara Zaria observed that polluted water wells of Samara were Due to poor location of such wells.

[13] Studied the quality of water wells found in Samaru Zaria and observed that all Wells were polluted with pollution strength varying with locational qualities, land use and well Construction design. He also observed seasonal variation in the population which he attributed to high total bacteria count levels in wells. Inadequate access to portable water studies in Bauchi metropolis is closely associated related to poverty. The objective of the study is to determine some physical, chemical and biological parameters of untreated water from hand dug Wells consumed and to compare the parameters with NIS, WHO and SON Standards in order to evaluate any possible health effect on the consumer. This is very important because drinking water quality guide lines and standards are designed to enable the Provision of clean and safe water for human consumption, thereby protecting human health as Well as environment [8].

The guide lines are usually based on scientifically acceptable levels of toxicity to either humans or aquatic organism. Water quality is not static overtime, rather, it vary in both time and space and acquires routine monitoring to detect spatial patterns and changes over time.

Methodology

The Study Area

The Dutsin Tanshi, Bauchi Nigeria lies between The Latitude and longitude of 10.294417, 10. 295222 and 9.836333, 9.837444 respectively; A number of human activities such as washing, dumping of refuse and domestic waste which take place along the wells. Most sources of water for domestic use in the study area are hand-dug wells. Thus provision of portable water stills standards high on the agenda of the people of the study area.

Data collection and analysis

Water samples were collected from sixteen [16] hand dug wells for both microbial and physicochemical analysis at different part of Dutsin Tanshi Bauchi on 24th may, 2014. In order to avoid microbial contaminations of sample container new polyethene gallon 1 liter was bought and carefully sterilized for physicochemical analysis. The gallon was rinsed with dilute nitric acid followed by washing with distilled water and with the sample from the source at the point of collection before sampling. The sampling bottles were labelled A1-A16 to represent sampling points sampling collection was done using available container between the period of 10:00am-12:00pm, and transportation to the laboratory was done within one hour from Federal Low-cost Housing Estate Bauchi to Abubakar Tatari Ali polytechnics Bauchi(A.T.A.P). The samples were stored in the refrigerator at temperature of 4°C until the completion of the analysis. This is to prevent any raised in temperature, which may encourage either the growth or death of Bacteriaand subsequently affect the reliability of the results [17]. Then from ATAP to Rural water supply and sanitation agency (RUWASSA). Test on microbial parameters was carried out within two weeks after sampling. water samples collected from each Hand dug wells were taken to the laboratory for analysis of the following parameters total and faecal coliform,the standard method for the determination of total and faecal coliform was employed [1].

Chemical Analysis

Photometric method was used for the determination of Ca^{2+},Mg^{2+},$SO_4^{2-}$$NO_3^-$,$Cl^-$. Each sample was analyzed for Ca^{2+},Mg^{2+},$SO_4^{2-}$$NO_3^-$,and Cl^- using the procedure outline in the palintest photometer method for examination of water [1]. Determination total hardness was done by titration method using E.D.T.A. A pH meters used for determination of pH, Turbidity meters used for turbidity, multifunctional conductivity meter was used for conductivity and TDS, and then spectrophotometer was used for determination of color. The results obtained were compared with secondary data gotten from publications of WHO standards to ascertain the conformity with the national and international guide lines.

Results and discussion

Table 1: Mean, Range and Standard Deviation of Physical, Chemical and Microbial Parameters of Analyzed Water Samples of Part of Federal Low-cost Housing Estate Bauchi.

Parameters	Range	Mean ±S.D	NIS	WHO
Temperature (^{0}C)	26.11-26.9	26.63 ±0.14	Ambient	Ambient
Conductivity (us/cm)	40-2670	1028.75 ±587.38	1000	1200
TDS (g/L)	200-1340	512.5 ±303.1061	500	1500
Turbidity (NTU)	0.3-9.69	1.8175 ±2.3693	5.0	5.0
pH	6.7-7.9	6.80625 ±0.5979	6.5-8.5	6.50-9.50
Colour	1-71	17.687 ±17.7415	3.0	15

Total Hardness (mg/L)	155-385	246.25 ±65.9927	150	500
Total alkalinity (mg/L)	20-165	80.31 ±50.18749	100	100
Calcium, Ca^{2+} (mg/L)	32-128	63.125 ±25.00499	750	NS
Magnesium, Mg^{2+} (mg/L)	4.88-48.63	15.3962 ±397885.00	0.20	2
Potassium, K^{+} (mg/L)	1.3-88	16.86875 ±22.66333	10	0
Sodium, Na^{+} (mg/L)	17.68-173.85	49.04625 ±28.57101		NS
Copper, Cu^{2+} (mg/L)	0.01-0.95	0.0916875 ±0.267	1.0	200
Manganese, Mn (mg/L)	0-0.006	4.375*10^-4 ±3.884*10^-4	0.2	2.0
Nitrate, NO_3 (mg/L)	14.72-225.28	123.26375 ±13.41	50	0.40
Sulphate, SO_4 (mg/L)	5-96	44.00 ±23.02	10	50
Chloride, Cl^{-} (mg/L)	23.04-236.8	117.7056 ±64.11	250	500
HCO_3 (mg/I)	24.4-201.3	97.45625 ±57.05		250
Total coliform (cfu/100ml)	0.0-890	173.4375 ±276.5277		100
Faecal coliform	0.0-366	55.25 ±101.9230	0	10

From the analysis of the samples, variations in the level of both physicochemical and microbiological concentrations were observed. The value of each parameters examined from sixteen [16] hand dug wells are tabulated. From the table above, result showed that most of the parameters with the exception of color pH were either above or below national and international standards. The value of temperature ranged from 26.11-26.9ºC and the mean 26.63 ºC, which is above WHO standards. High temperature causes thermal pollution and adversely affects aquatic life [8]. It is noted that high water temperature enhances the grow of microorganisms and may increase odor, and correction problems [18].

Rise in water temperature lower the viscosity of water and cause faster settling of solid particle [8]. The pH in all the water samples has the values 6.7-7.9 and the mean of 6.8 which is within the standard of WHO and NSDWQ in Nigeria. The pH value lower than 6.5 is considered too acidic for human consumption and can cause problems such as acidocis. The pH value greater than 8.5 is considered to be too alkaline for human consumption [1]. Although pH usually has no direct impact on consumer it is one of the most important operational water quality parameter [18]. Though pH has no direct effect on the Human health all the biochemical reaction are sensitive to variations of pH. For most reactions as well as for human being, pH value 7.0 is considered as ideal [10]. Even though pH has no direct effect on human health, its indirect reaction on physiological process cannot be over emphasized [3]. The color ranged between (1-71) cfu and the mean was 17.74 cfu which is above the WHO permissible limits. Only water samples from eight (8) hand dug wells HDW, 1, 6, 9, 10, 12, 13, 15 and 16 show the value of 18,32,35,16,29,18,20 and 71 cfu respectively which exceeded the WHO STANDARD for drinking water. The color in drinking water is due to the presences of colour organic matter (primarily holmium) associated with human fiction of soil or the presences of ion and other metals either as natural impurities or correction [19]. Color in water is a reflection of the present of suspended matter. The greater the suspended matter in water the greater will be the color [17].

The conductivity concentrations ranged between (40-2670) µs/cm and the mean was 1028 µs/cm which exceeded the WHO permissible limits. Only water sample from seven HDW namely;HDW, 2, 5, 6, 11, 12, 15 and 16 show the value 1130, 1740, 2670, 1340, 1160, 1200 and 1680 µs/cm respectively which exceeded the limits of WHO standards. The excess conductivity causes cataract, diuretics disease and diarrhea in many and scouring disease in livestock [8, 20, 21], stated that electrical conductivity is not a good indicator of water quality with regard to health hazard. It is however, an indicator of salinity which is an important factor in taste and taste is an important factor in user acceptance of water points [9]. WHO does not directly consider electrical conductivity as guide line for drinking water quality, but it does give recommendation for the dissolved solid because of taste consideration [19]. The turbidity values ranged between 0.3-9.69 NTU and the mean 1.8175 NTU which is below the WHO permissible limits. Only water samples from HDW 16 which exceeded the WHO standard for drinking water. Turbidity measures the degree to which water loses its transparency due to present of suspended particles [17]. High turbidity can protect microorganism from the effect of disinfection thereby can stimulate with bacterial growth [22, 23]. According to [20], turbidity does not have effect on health but high turbidity reduces the effectiveness of disinfection procedure because microorganism can be protected from disinfection by suspended materials. In addition, turbid water is less acceptable to consumer from an aesthetic view point [19]. Water turbidity is very important because high turbidity is often associated with higher level of disease causing microorganism such as bacteria and other parasite [8]. The range of total hardness from the analyzed water sample was155-385) mg/L and then mean was 246.25mg/L which exceeded the limits of NIS/WHO. Hardness is refers to total concentration of calcium and magnesium in water; It also measure the capacity of water to precipitate soap [17]. Total hardness of water depends mainly upon the amount of divalent metallic cations of which Ca^{2+} and Mg^{2+} are more abundant to ground water [17]. The range of Chloride from the analyzed water samples was (23.04-236.8)mg/L and the mean was 117.705625mg/L which is below WHO permissible limits. Chloride are usually found in form of salts of sodium, potassium and calcium (NaCl,KCl and $CaCl_2$) [17]. However chloride in excess about 250mg/L can givers to detectable taste in water [18, 19]. The total dissolved solid from the analyzed water samples were ranged from 200-1340 mg/L and the mean was 512.5mg/L, which exceeded the WHO permissible limits. only water samples from hand dug wells namely; HDW,2,5,6,11,12,15 and 16 show the value 560,870,1340,670,580600and840 mg/L respectively which exceeded the WHO permissible limits. Ground water with

TDS<600mg/L (Electrical conductivity about 1200.00us/cm) becomes progressively become less portable [9].

The Calcium values from the analyzed water samples ranged from 32-128 mg/L and the mean 63.125mg/L which is below the maximum permissible limits. Calcium is an element that is found naturally in abundance within the earth's crust. It is an important element in human body. Adequate intake of Calcium is essential for normal growth and good health. Calcium is the most important element that causes hardness of water [17]. Calcium intake is important at all ages but the need for calcium is higher during childhood, fetal growth, pregnancy and lactation. A diet fortified with calcium may reduce the risk of osteoporosis and it decreases the neuromuscular excitability, plays important role in myocardial system, heart and muscles contraction, intracellular inflammation, transmission and blood clothing [2].

At high levels (in combination with magnesium) it can causes incrustation on utensils and scale deposits in water heater and boiler tubing. It also reduces soap lather [25]. The range of magnesium from the analyzed water samples were 4.88-48.63 mg/L and the mean is 15.39625mg/L which is within the WHO permissible limit. Only water samples from hand dug wells namely; HDW, 2, 7, 10, 12 and 13 which show the values 27.68, 48.65, 29.3, 20.76and21.37) respectively which were above the permissible limits. Magnesium is a major constituent of the dark-colored minerals associated with igneous rocks Sedimentary sources of magnesium include carbonates and dolomites [25]. It is an important element that is essential for plant and animals nutrition [25]. In humans, magnesium is a cofactor in more than 300 enzymatic reactions, particularly that involving energy utilization [2].

Calcium and magnesium however, are needed by the body in much larger quantities and their lack in the human system will lead to adverse health effect [1]. The range of Sodium from the analyzed water samples were 17.68-173.85mg/L and the mean was 49.04625mg/L, which is below the NIS permissible limits. Sodium is an essential element for maintaining good Health [14]. Numerous studies have shown that Na^+ intake is associated with hypertension and dietary Na^+restriction achieved by not adding salt and avoiding Na^+ rich food may effectively reduce blood pressure. An excess of sodium more than 200mg/L may cause salty taste or odor as wells present long term health effects. This is a key element in water and is essential for health. In healthy adults excess sodium is excreted but in sensitive adults high Na^+ Levels may cause problems [2]. The range of copper from the analyzed water samples were0.01-0.95mg/L and the mean was 0.0916875mg/L which is within NIS permissible limits copper is an essential element for maintaining good health.A deficiency may results in anemia loss of pigment and reduce growth[25]. Copper is an essential element in human metabolism and its deficiency results in variety of clinical disorders including nutritional anemia, particularly infants [17]. Copper levels in drinking water are usually low at only few micrograms per liters but copper plumbing may result in greatly increased concentrations. Concentrations can rich several milligrams per liters following stagnation in pipes [26]. Copper is an essential nutrient, but at high doses it has been shown to cause stomach and intestinal distress, liver, kidney damaged anemia [4]. Copper is both an important nutrient and drinking water contaminant. Oxidative damage to biological systems takes place at higher concentration of copper [2]. The range of chromium from the analyzed water samples were 0.00-0.05 mg/L and the mean was 0.01625mg/L which is below the NIS and WHO permissible limits. Chromium (Cr) is naturally occurring metallic element occurring most frequently in igneous rocks and trivalent chromium ($Cr3^+$) is an essential element for maintaining good health; a deficiency may result in atherosclerosis [25]. The range of manganese from the analyzed water samples were 0-0.006 mg/L and the mean was 4.37 - 10.4 mg/L which is below the WHO permissible limits.

Manganese (Mn) concentrations in ground water are usually low with elevated levels occurring in brines and thermal springs. It is an essential element for maintaining good health. Higher levels can stain laundry and plumping and causes taste problems [25]. Manganese is an essential element for humans and other animals. Adverse effects can result from both deficiency and over exposure. Manganese is kown to cause neurological effects following inhalation, lethargies and symptoms stimulating Parkinson's syndrome [2]. The range of total alkalinity from the analyzed water samples were 20-165 mg/L and the mean was 80.31mg/L, which is below the NIS maximum permissible limits. Only water samples from hand dug wells five hand dug wells namely; HDW,2,5,11,15and16 show the values 125,165,155,120and 120 mg/L, respectively high alkalinity may cause an unpleasant taste. It is also detrimental to industrial processes and may affect irrigated crop [25]. The range of Nitrate from the analyzed water samples was 14.75-225.28 mg/L and the mean was123. 2637mg/L which exceeded NIS permissible limits. Only water samples from HDW2shows the value of 14.72mg/L which is below NIS permissible limits. It is essential element for maintaining good health. High levels can stain laundry and plumping and cause taste problems [25]. Excess nitrate in drinking water causes cyanosis and asphyxia (blue baby syndrome) in infants less than 3 months [24].

Ground water in agricultural area are usually known to originate from fertilizers while in nonagricultural area, ground water nitrate could be attributed to disposal of human excreta and domestic sewage [9]. The sources of ground water nitrate contamination include septic tank, sewage treatment plants and animal waste, commercial fertilizers, nitric acid waste natural geologic sources, lighting and radiations, create nitrate in the atmosphere where rain storm carry them to the ground [28, 29, 30]. The range of sulphate from the analyzed water samples were 5 - 96 mg/L and the mean was 44mg/L which is below NIS maximum permissible limits. Sulphate minerals are widely distributed in nature and sulphate anion is common constituent of unpolluted water [17]. Sulphate occur naturally and disband magnesium salt from rocks and soil containing gympsun, iron sulfides, and other sulphur compound. High levels can give water a bitter taste, rotten egg smell and cause diarrhea [25]. Drinking water containing high concentration of sulphate caused by leaching of natural deposit of magnesium sulphate or sodium sulphate may be undesirable because of their laxative effect offensive taste and increase in corrosive properties of water [31]. Bicarbonates and carbonate produce alkalinity. Bicarbonates of calcium decomposed in steam boilers to form scale and release corrosive carbon dioxide gas

[25]. From the result of analysis the HCO^{3-} values has the range between 24.4-201.3 mg/L and the mean of 97.45625mg/L this means that the HCO3- values in some samples were below the maximum permissible limits while some others were above the maximum permissible limits of 100mg/L recommended by NIS. The range value of Total coliform from the analysed water samples were 0 - 890 cfu/100ml and the mean was 173.4375cfu/100ml. Only water samples from seven (7) water samples HDW;1,5,6,8,13,14 and 15 showed the values of 93, 81, 540, 196, 890, 576 and 70 cfu/100ml respectively which are not safe for drinking. Coliform Bacteria are described by grouping based on their common origin or characteristics as either total or faecal coliforms. The total group include faecal coliform bacteria such as eschericia coli (E.coli) and other coliform bacteria that are naturally found in soil. Faecal coliform bacteria exists in the intestine of human beings and animals and are released through waste discharges into the soil. Coliform bacteria are used as indicators for water quality because of their presence in drinking water may indicate possible presence of harmful disease causing organism. Their detection in drinking water is also relatively simple and economical [17]. The range value of faecal coliform from the analyzed water samples were 0-245cfu/100ml and the mean was 31.2cfu/100ml only water samples from seven (7) water samples HDW1,5,6,8,14,14,and 15 show the values 13,22,160,57,366,187 and79 cfu/100ml respectively which exceeded the permissible limits of NIS. Accoding to WHO standard no coliform should be detected at all in any 100mlof drinking water [17].

Conclusion

From the study, it was observed that water quality of sixteen (16) hand dug wells present a vivid picture of the nature of pollutants found in hand dug wells water where many consumers rely on. This means that the water from most wells is not in any way suitable for direct consumption. However to avoid further pollution of ground water, (hand dug wells), the study recommends that the site of any well to be dug should be at least 30m away from sources of contaminations, the surrounding environment should be kept clean and tidy to avoid or minimize contamination from dirt around the wells. Disinfection of hand dug wells water by chlorination and continuous monitoring to determine any change in the levels of pollution is emphasized.

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