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Assessment of the quality of water from hand dug wells and boreholes at federal low: Cost housing estate Bauchi, Bauchi state, Nigeria

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Abstract

This study assessed the water quality of some hand dug wells and boreholes within federal low-cost Housing Estate, Bauchi Local Government Area of Bauchi State, Nigeria. Water samples collected from sixteen (16) different wells and four(4) different Boreholes at Strategic positions and determined to ascertain how safe the water is for direct 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, 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 mean parameters and their ranges were :Temperature 26.6(26.2-27) ºC, Conductivity 9970.6(108-3220)us/cm, T.D.S. 611.5(130-4040)mg/L, Turbidity 1.992(0-7.7) NTU, pH7.385 (6.8-7.80), Colour 14.8(0-67), total Hardness as CaCO3 26.575(95-480) mg/L, Total Alkalinity as $CaCO_3$ 105.75(10-320)mg/L, Ca^{2+},81.6 (32-134)mg/L, K^+ 13.495 (1.3-88)mg/L, Mg^{2+}15.11 (2.44-32.96)mg/L, Na^+65.3144(17.68-1738)mg/L, Cu^{2+}0.268(0.01-1.42)mg/L, Cr^{3+}5*10^-4(0-0.12)mg/L, $NO3^{2-}$121.68(18.48-190.08)mg/L SO_4^{2-}36.9590-70)mg/L, Cl^-160.793(44.94-392)mg/L, HCO_3^-129.015(12.2-390mg/L, Total coliform 56.95(0-596) cfu/100ml, Faecal coliforms 31.2 (0-245)cfu/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 and bore holes in the study area is not suitable for direct human consumption. The closeness of wells and boreholes 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 and a boreholes 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 with chlorine and continuous monitoring to determine any Change in the level of pollution at source was emphasized.

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]. Water plays and indispensable role in sustenance of life and it is key pillar health Determinant, since 80%of diseases in developing countries are due to lack of good quality Water [3]. Unfortunately, in many states around the conutry including Bauchi, water has become a scarce commodity as only a small portion of the 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 residents who do not have access to treated 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].

The need to assess the quality of water from source of these alternatives has become imperative because they have direct Effect on the health of individuals [1]. Waters that are likely contaminated by disease causing agent, if consumed May posed at the same Time cause different health hazards and problems [5]. Contaminated water is a global health threat placing people at risk of host of diarrhea and other illness as well as chemical intoxication [3]. 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 for good health [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 ground water is affected by location, construction, and operation of wells [4] 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 is an important source of drinking water for human kind, it contains over 90%of fresh water Resources and it is an important reserve of good water quality [4]. Even if no sources of anthropogenic Contamination exist there is a potential for natural level of minerals and other chemicals to be harmful to Health [1]. 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 Samaru Zaria observed that polluted water wells of Samaru 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 variations in the population which he attributed to high total bacteria count levels in wells. Inadequate access to portable water studied in Bauchi metropolis is closely related to poverty. The objective of the study is to Determine some physical, chemical and biological parameters of untreated water from hand dug Wells and boreholes 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

Federal low-cost housing estate Bauchi is located between the Latitude and longitude of 10.2833 and 9.883 respectively; and it Can be mapped to closet address of Federal Lowcost ECWA Church, Bauchi, Nigeria [17]. The sampling points lies Between Latitude 10º17´22.70˝N and Longitude 9º49´33.94˝E to latitude 10.312000N and Longitude 9.854111E. There is well planned in modern layout where Houses are built to modern design standards. However, a number of human activities such as washing, dumping of refuse and domestic waste which take place along the wells and bore holes. Most sources of water for domestic use in the study area are hand-dug wells and a boreholes. Thus provision of portable water still remains a huge challenge to the inhabitants.

Data collection and analysis

Water samples were collected for both microbial and physicochemical analysis from sixteen [16] hand dug wells and four [4] boreholes at different part of federal low-cost Housing estate Bauchi on 24th may, 2014. In order to avoid microbial contaminations of sample containers, 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 labeled A1 - A20 to represent sampling point. Sampling collection was done using available containers from 10:00am - 12:00pm, the samples collected were transported to laboratory 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 4ºC until the completion of the analysis. This is to prevent any increase in temperature, which may encourage either the growth or death of Bacteria and subsequently affect the reliability of the results [18]. Then from ATAP to Rural water supply and sanitation agency (RUWASSA) for analysis. Test on microbial parameters were carried out within two weeks after sampling.

Chemical Analysis

A 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 of 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, then spectrophotometer was used for determination of color. The results obtained were compared with secondary data gotten from publications of WHO standards to ascertain 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	SON	WHO
Temperature (^{0}C)	26.6 – 27	26.86	0.169	Ambient
Conductivity (us/cm)	108-3220	9970.60 ±734.33	1000	1200
TDS (g/L)	130-4040	611.50 ±838.13	500	1500
Turbidity (NTU)	0-7.7	1.92 ±2.72	5.0	5.0
pH	6.6-7.8	7.39 ±0.31	6.5-8.5	6.50-9.50
Colour	0-67	14.80 ±19.75	15	15
Total Hardness (mg/L)	95-480	265.75 ± 461.61	150	500

Total alkalinity (mg/L)	10-320	105.75 ±30.52	750	NS
Calcium, Ca^{2+} (mg/L)	32-134	81.60 ±31.12	10	NS
Magnesium, Mg^{2+} (mg/L	2.44-32.96	15.21± 8.02	-	10
Potassium, K^{+} (mg/L)	1.3-88	13.50 ±19.84	3.0	3.0
Sodium, Na^{+} (mg/L)	17.68-173.83	65.31 ±44.94	NS	NS
Copper, Cu^{2+} (mg/L)	0.01-1.42	0.27	2.0	0.40
Manganese, Mn (mg/L)	0-	5*10^-4 ±0.014	2.0	0.40
Nitrate, NO_3 (mg/L)	18.48-190.08	121.60 ±44.05	50	50
Sulphate, SO_4 (mg/L)	0-70	36.95 ±19.86	100	100
Chloride, Cl^{-} (mg/L)	44.99-392.38	160.79 ±103.44	250	250
HCO3 (mg/I)	12.2-3 90.4	129.02 ±105.27		
Total coliform (cfu/100ml)	0-596	86.95 ±162.25		
Faecal coliform (cfu/100ml	0-245	31.20 ±63.87		

The range, mean and the standard deviation values for physicochemical and microbial parameters determined in hand dug wells and boreholes shown in the table below. Temperature ranged from (26.2-27)ºC and mean was 26.6ºC, Which is above the WHO standards. High temperature causes thermal pollution and adversely affects aquatic life [3]. It is noted that high water temperature enhances the grow of microorganism and may increase odor [19].

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 range of (6.8-7.8) and the mean 7.39 which was within the standard of WHO and NSDWQ in Nigeria. The pH value lower than 6.5 are considered too acidic for human consumption and can cause problems such as acidosis. The pH value greater than 8.5 are 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 [19]. Though pH has no direct effect on the Human health,all the biochemical reaction are sensitive to variation of pH for most reaction as well as for human being, pH value 7.0 is considered as best 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 (0 -67) cfu and the mean was 14.8 cfu which is within the WHO permissible limits. Only water sample from six(6) hand dug wells namely; HDW,8,14,16,18,19,20 and one (1) borehole BHW 12 show the value of 24,24,44,26,50,30 and 67 cfu respectively which exceeded the WHO STANDARD for drinking water. The color in drinking water is due to presence of color organic matter (primarily holmium) associated with human fiction of soil or the present of ion and other metal either as natural impurities or correction [20]. 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 [18].

The conductivity concentration ranged between (108-3220) µs/cm and the mean was 9970.6 µs/cm which is below the WHO permissible limits. only water sample from six HDW namely;HDW,4,8,9,13,19, and 20 µs/cm and one borehole BHW12 show the value 1104,2440,1210,1640,1207,1113 and 3220 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, 21, 22], 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 [9]. The turbidity values ranged between (0-17.93) NTU and the mean 151.922 NTU which is below the WHO permissible limits. Only water samples from HDW 19 which exceeded the WHO standard for drinking water. Turbidity measure the degree to which water loses its transparency due to present of suspended particles [18]. High turbidity can protect microorganism from the effect of disinfection thereby can stimulate with bacterial growth [23, 24]. According to [21], 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 [9]. Water turbidity is very important because high turbidity is often associated with higher level of disease causing microorganism such as bacteria and other parasite [3]. The range of total hardness from the analyzed water sample was (95-480) mg/L and then mean was 265.75mg/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 [18]. 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 [7]. The range of Chloride from the analyzed water samples was (44.99-392.38)mg/L and the mean was 160.793mg/L which is below WHO permissible limits. Only water samples from hand dug wells namely; HDW, 8, 13, 16, and BHW12 shows the value of 372. 38, 262.42.392.38, and348.9 mg/L respectively which exceeded the **WHO** permissible limits. Chloride are usually found in form of salts of sodium, potassium and calcium (NaCl, KCl and $CaCl_2$) [18]. However chloride in excess about 250mg/L gives detectable taste in water [25,26]. The total dissolved solid from the analyzed water samples were ranged from (130-4040)mg/L and the mean was611.5mg/L, which exceeded the WHO permissible limits. Only water samples from hand dug wells namely; HDW, 4, 6, 8, 9, 13, 19, 20 and BHW12 the value 570, 540, 1220, 600, 820, 630, 560 and 1610 mg/L respectively 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 (32-1340mg/L) and the mean was 81.6mg/L which is above the maximum permissible limits. Only water samples from Hand dug wells namely; HDW,6,8,9,13,14,16,19 and 20 and BHW12 show the values (90,142,90,84,114,148,90,134 and 76) mg/L respectively, which exceeded the permissible limits. Calcium is an element that is found naturally in abundance within the earth's crust. It is also an important element in human body. Adequate intake of Calcium is essential for normal growth and good health. Calcium causes hardness in water [18]. 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 reduce soap lather [27]. The range of magnesium from the analyzed water samples were (2.44-32.96)mg/L and the mean is 15.21mg/L which exceeded the NIS permissible limit. Only water samples from hand dug wells namely; HDW, 13,14,16,20 mg/L and bore hole BHW12 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 [27]. it is an important element that is essential for plant and animals nutrition [27]. In humans, magnesium is 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 (17.68-173.83)mg/L and the mean was 65.314mg/L, which is below the NIS permissible limits. Sodium is an essential element for maintaining good Health [27]. Several 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 good 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 were (0.01-1.42)mg/L and the mean was 0.268 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 [27]. Only water samples from hand dug wells namely; HDW,14,16 mg/L and BHW12 show the values of 1.03,1.42 and 1.27mg/L respectively which exceeded the NIS permissible limits copper is an essential element in human metabolism and its deficiency results in variety of clinical disorders including nutritional anemia, particularly in infants [18]. Copper levels in drinking water are usually low at only few micrograms per liters but copper plumbing may result in greatly increased concentrations. Concentrations may reach several milligrams per liters following stagnation in pipes [28]. 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 element and drinking water contaminant. Oxidative damage to biological systems take place at higher concentration of copper [2]. The range of chromium from the analyzed water samples were (0-0.12) mg/L and the mean was 0.0395mg/L which is below the NIS and WHO permissible limits.

HDW, 18 and 20 show the values (0.06 and 0.06) mg/L respectively which exceeded the maximum 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, deficiency may result in atherosclerosis [27]. The range of manganese from the analyzed water samples were (0-0.04) mg/L and the mean was 4.0 – 5.10 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 [27]. 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 (10-320) mg/L and the mean was 105.75mg/L, which exceeded the NIS maximum permissible limits. Only water samples from hand dug wells eight hand dug wells and two boreholes namely; HDW, 4, 8, 13, 14, 16, 17, 19, 20 and BHW 11 and 12 show the values 120,280,210,120,160,140,105,115 and 140 and 320 mg/L, respectively. High alkalinity may cause an unpleasant taste. It is also detrimental to industrial processes and may affect irrigated crop [27]. The range of Nitrate from the analyzed water samples was (18.48-190.08)mg/L and the mean was121.68mg/L which exceeded NIS permissible limits. Only water samples from BHW12 shows the values 18.48mg/L which is below NIS permissible limits. It is an essential element for maintaining good health. High levels can stain laundry and plumping and cause taste problems [27]. Excess nitrate in drinking water can cause cyanosis and asphyxia (blue baby syndrome) in infants less than 3 months [25].

Ground water contamination of nitrate in agricultural area is known to originate from fertilizers while in nonagricultural area ground water nitrate could be attributed to disposal of human excrete 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 [29, 30, 31]. The range of sulphate from the analyzed water samples were (0-70) mg/L and the mean was 36.95mg/L which is below NIS maximum permissible limits. Sulphate minerals are widely distributed in nature and sulphate anion is common constituent of unpolluted water [31]. Sulphate occur naturally and disband magnesium solved from rocks and soil containing gypsum, iron sulfides, and other sulphur compound. High levels can give water a bitter taste, rotten egg smell and cause diarrhea [27]. 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 [32]. Bicarbonates and carbonate produce alkalinity. Bicarbonates of calcium decomposed in steam boilers to form scale and release corrosive carbon dioxide gas [27]. From the result of analysis the HCO^{3-} values has the range between 12.2-390.0mg/L and the mean of 129.015mg/L this means that the HCO^{3-} values in some samples were below the maximum permissible limits while some were above the maximum permissible limits of 100mg/L recommended by NIS.

Only water samples from HDW;1,3,5,6,7,10,15,18 and BHW2 show the values 24.4, 36.6,67.1, 67.1,24.4, 48.8, 12.2and 54.9mg/L which were below the maximum permissible limits. The range of Total coliform from the analyzed water samples were,0-596 cfu/100ml and the mean was 86.95cfu/100ml. Only water samples from water samples HDW; 6,8,9,13,14 and BHW12 show the values of 596, 266, 209, 76, 238, and 357_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 exist in the intestine of human being and animals and are released through waste discharges into the soil. Coliform bacteria are used as indicators of water quality because 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 [18]. 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 six(6) water samples HDW6,8,9,,13,14, and BHW 12 show the values 245,99,46,14,92, and 128cfu/100ml respectively which exceeded the permissible limits of NIS. These high values might be attributed to proximity of water bodies to gutter, dumpsites, and pit latrines [33]. According to WHO standard no coliform should be detected at all in any 100mlof drinking water [18].

Conclusion

From the study, it was observed that water quality of sixteen (16) hand dug wells and four (4) boreholes present a vivid picture of the nature of pollutants found in hand dug wells and a bore hole water where many consumers rely on as sources of drinking water. This means that the water from most wells and boreholes is not in any way suitable for direct consumption. However to avoid further pollution of the ground water,(hand dug wells and boreholes), the study recommends that the site of any well and borehole dug should be at least 30m away from source of contaminations; The surrounding environment should be kept clean and tidy to avoid or minimize contamination from dirt around the wells and bore holes, disinfection of hand dug wells and boreholes water by chlorination and continuous monitoring to determine any change in the levels pollution at the sources.

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