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Water quality assessment of some selected hand dug wells in parts of southern Bauchi metropolis

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Abstract
Ten water samples were collected and analyzed for physicochemical and microbial parameters. These parameters include temperature 27.22ºC (27-27.6ºC) Turbidity 15.9 (2-70) NTU, Conductivity 447.4 (138-1038) µs/cm, T.D.S. 223.6 (69-519) mg/L, Ca^{2+} 44.76 (2.6-80) mg/L, Mg^{2+} 6.011 (0.02-22.5) mg/L, Cu^{2+} 0.143 (0-0.36) mg/L, F^- 0.415 (0.06-0.78) mg/L, NO_3^{2-}58.826 (9.02-221) mg/L, Cl^- 87.25 (25-190) mg/L and Cr^{3+} 0.0124 (0-0.0031) mg/L. Total coliform 84.3 (36-176) cfu/100ml and faecal coliform 37 (0-100) cfu/100ml. The result revealed high variation between WHO, SON, NIS and NSDWQ Standards for potable water and the obtained values. The implication is that the water from most of the study area is not suitable for direct human consumption. The closeness of the source of water to dumpsites was blamed for increased levels of the parameters obtained.

Keywords: water quality assessment, physicochemical and microbial parameters, WHO, SON, NIS and NSDWQ Standards Hand Dug-wells, Southern Bauchi Metropolis, Nigeria

Introduction

Water is the basic element for live and survival in the earth planet [1, 2, 3]. Safe and good quality drinking water is fundamental for good health [1, 4, 5]. Good quality is of basic importance for human physiology and the humans life depend basically on availability [1, 6].

Quality drinking water is essential for live [7] unfortunately, in many States around the nation including Bauchi, water has become a scarce commodity as only small portion of the populace has access to treated water. In Bauchi metropolis adequate supply of portable water is lacking [2, 5]. Alternative sources of water such as ground water and rain water have become major sources of drinking water for people living in new settlement and some resident who do not have access to treated water in Bauchi. The need to assess the quality of water from some of these alternative sources has become imperative because they have a direct effect on the health of individuals [2, 9]. The quality of water used for drinking or any domestic purpose is important factor in public [10]. Poor quality water can cause a disease outbreak and according to world health organization about 40% of the diseases in the world are due to consumption of polluted ground water [11] and in developing countries about 75% of diseases are induced by polluted water [12]. Quality (physical, chemical and microbiological) analysis of drinking water provides important evidence about the sources of water pollution and guidelines for health protection [13]. Quality and safety of the drinking water are important in public health issue [14]. Ground water contamination is responsible for water related and water borne disease in developing countries like Nigeria, evaluation of ground water quality for human consumption is essential to human existence [15]. The source of ground water contamination could be natural through ground water-rock interaction or through anthropogenic which involve human activities that can affect ground water quality [15]. Ground water pollution which is man-made is worse than natural pollution as it eventually renders water unsuitable for use than original state [15, 16]. Ideally water should not contain any microorganism known to be pathogenic [17]. Impure water can contain the bacteria responsible for typhoid and cholera [1]. Dug wells are generally the worst ground water sources in terms of faecal contamination, and bacteriological analysis serves primarily to demonstrate the intensity of contamination and hence level of risk to consumer [19]. However, ground water is generally a very good source of drinking water because of purification properties of the soil [20]. In Nigeria studies [21, 22, 23, 24] have observed water pollution in Hand Dug Wells due to factors such as poor location of wells land use and construction standards of the wells. The objectives of the study is to determine some physical, chemical and biological parameters of untreated water from hand dug wells consumed and to compare the parameter with NIS, WHO, and SON standards in order to evaluate any possible health effect on the consumers. 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 [20]. 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 requires routine monitoring to defect spatial patterns and changes overtime.

Methodology

Study Area

Bauchi is an urban city in Bauchi State, North-Eastern

Nigeria. The study area lies between latitudes1134263ºN and 1138708ºN and longitudes 585407ºE and 594180ºE on a scale of 1:50, 000, South West of sheet 149 NE Bauchi. The area is generally accessible through a tarred road, an untarred road, minor roads and footpaths that link the various settlements.

Water samples were collected from ten (10) different sampling points at specific locations in Southern part of Bauchi metropolis in the month of May, 2012 from hand dug wells, boreholes, ponds and streams from Yelwan Makaranta, Yelwan Tudu, Kagadama, Rafin Zurfi, Gwallameji, Lushi, Gudum Hausawa and Gudum Sayawa. Sample bottles were treated with dilute nitric acid followed by repeated washing with distilled water and with the water source sampling. The sampling bottles were labeled E1-E10 to represent the sampling point. Sampling collection was done using the available container between the periods of 10-12 pm. And transportation to the laboratory was done within one hour to the rural water supply and sanitation agency (RUWASSA), Bauchi, Nigeria. Test on biological parameters was carried out within two weeks after sampling. The samples were stored in the refrigerator at temperature of 4ºC until completion of the analysis. This is to prevent any rise in temperature, while which may encourage either the growth or death of microorganism.

Physico-chemical analysis

For conductivity, total dissolved solids and temperature determination a digital conductivity/TDS meter model 44600 was used. Photometric method was used for the determination of total, Copper Cu^{2+}, nitrate NO_3^{2-}, chloride Cl^-, chromium Cr^{3+}, Calcium Ca^{2+}, Magnesium Mg^{2+}, Fluoride F^-, determination of total hardness was carried out using titration method, each sample was analyzed for all the parameters.

The results obtained were compared with secondary data gotten from publications of world health organization (WHO) standard to ascertain the conformity with the national and international guidelines [20].

Result and discussion

FROM ANALYSIS of the samples, variations in the level of physico-chemical and microbiological concentration were observed. The value of each parameters examined from the ten water sample are tabulated in table one (1). Table two (2) which is a summary of data in table1 shows the variation in terms of range, mean and standard deviation level of concentration of each parameter examined, WHO Standard and deviation from these standards [20].

Table 1: Combined Result of Physical, Chemical and Microbiological Parameters of Analyzed Water Samples in Some Parts of Southern Bauchi Metropolis and Environ

Location Parameter	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**
Temperature	27	27.3	27.6	27.3	27.2	27.3	27.1	27.4	27	27
pH	6.9	6.6	6.9	7	6.7	6.9	6.5	6.9	6.8	6.9
Turbidity	17	2	10	70	9	2	27	2	3	17
Electrical Conductivity	517	395	1038	360	690	695	138	160	260	220
Total Dissolved Solids	259	179	519	180	345	365	69	80	130	110
Total Hardness	210	100	275	110	280	185	30	75	70	90
Bicarbonate	180	79	203	68	243	164	23	67	60	76
Ca^{2+}	67.2	36	89	40	75.2	72	12	24.8	2.6	28.8
Mg^{2+}	10.26	2.44	12.51	2.44	22.5	1.22	0.02	3.14	1.22	4.36
Fe^{2+}	0.04	0.142	0	0	0.25	0.02	0	0.041	0.05	0.161
Cu^{2+}	0.02	0	0.32	0.27	0	0.051	0	0.21	0.36	0.205
F^-	0.41	0.396	0.68	0.78	0. 26	0.242	0.341	0.164	0.06	0.66
Zn^{2+}	1.5	0	0.271	0	1.031	0	0	0.73	0.071	0
NO_3^-	9.02	57.01	101.2	47	23.43	221	26.1	23.43	45.06	35.01
NO_2^-	0.043	0.178	0.297	0.337	0.277	1.439	0.138	0.139	0.187	0.231
Pb^{2+}	0	0	0	0	0	0	0	0	0	0.001
SO_4^{2-}	124	70.3	204	46	145	82	21	53.1	51	31
Cl^-	112.5	60	190	70	135	143	35	25	64	38
Sal NaCl	119.3	63.57	201.3	74.18	143.06	154	37.09	26.49	66.22	39.74
Cr^{3+}	0.021	0	0.006	0.031	0.014	0	0.02	0.03	0.002	0
K^+	102	46.7	122	71	124	140	0.451	0.12	20.43	10.45
T.colifom	36	176	103	87	54	103	45	78	107	54
F.colifom	0	100	30	20	10	70	20	50	50	20

Table 2: Mean, Range and Standard Deviation of Physical, Chemical and Microbial Parameters of Analyzed Water Samples of Parts of Southern Bauchi Metropolis.

Parameters	Range	Mean S.D	SON	WHO/ NSDWQ
Temperature (ºC)	27-27.6	27.22±0.198886	Ambient	**NIS*MPL**
Conductivity (us/cm)	138-1038	447.3±288.5508	1000	0.169
TDS (g/L)	69-519	223.6±146.5622500	1500	1200
Turbidity (NTU)	2-70	15.9±20.76562	5.	500
pH	6.5-7	6.	6.5-8.5	5.0
Colour	0-67	14.80 ±19.75	15	6.50
Total Hardness (mg/L)	30-280	142.5±88.76467	150	15
Calcium, Ca^{2+} (mg/L)	2.6-89	44.76±29.31163	750	500
Iron, Fe^{2+} (mg/L)	0-0.25	0.		NS
Magnesium, Mg^{2+} (mg/L)	0.02-22.5	6.011±7.074603	10	0.3
Sodium, Na^{+} (mg/L)	17.68-173.83	65.31 ±44.94	3.0	0.2
Copper, Cu^{2+} (mg/L)	0-0.36	0.1436±0.144459	NS	3.0
Flouride,F^{-}(mg/L)	0.06- 0.78	0.414778±0.247056		1.0
Zinc,Zn^{2+} (mg/L)	0-1.5	0.3603±0.540183		1.0
Chromium,Cr^{3+}(mg/L)	0-0.031	0.0124±0.012474		3.0
Nitrate, NO_3 (mg/L)	9.02-221	58.826±62.40833	50	0.05
NO_2	0.043-1.439	0.3266±0.400386		50
Lead.Pb^{2+} (mg/L)	0-0.001	0.0001±0.000316		0.2
Sulphate, SO_4 (mg/L)	21-204	82.74±57.8913	100	0.001
Chloride, Cl^{-} (mg/L)	25-190	87.25±54.96931	250	10
Sal NaCl,(mg/L)	26.49-201.3	92.495±58.65971		25
Potassium,K^{+}	0.12-140	63.7151±55.19315		-
HCO_3 (mg/I)	23-243	116.3±74.204		-
Total coliform (cfu/100ml)	36-176	84.3±41.34422		100
Faecal coliform (cfu/100ml)	0-100	37±30.56868		0

NSDWQ – Standard for Drinking Water Quality, *MPL – Maximum Permisible Limits

Water quality assessment for these studies is based on the maximum permissible limits (MPL) of Nigeria standard for drinking water quality (NSDWQ) of Nigerian industrial standard [6, 27] and world health organization [28].

The value of temperature range from 27-27.6ºC and the mean is 27.22ºC. This is above the WHO standard. The water sample from highest temperature causes thermal pollution and adversely affects aquatic life [20]. It is noted that high water temperature enhances the growth of microorganism and may increase taste, odour and corrosion problem [29]. More so, a rising water temperature lowers the viscosity of water and causes faster settling of solids particles [27]. The pH in all the water sample has the range of 6.5-7 and the mean 6.8 which are 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 health problems such as acidosis. The pH value greater than 8.5 are considered to be too alkaline to human consumption [30]. Although pH usually has no direct impact on consumers is one of the most important operational water quality parameter [29]. The conductivity concentration ranged between 138-1038us/cm and the mean is 447.3 µs/cm which is below the WHO permissible limits. Only water sample from one sampling point which is E3 shows the value 1038 µs/cm which exceeded the WHO permissible limit. Excess conductivity causes tract, dietetics disease and diarrhea and scouring disease in livestock [20]. Langeneger (1994) and Adakole (2007) stated that electrical conductivity is not a good indicator of water quality with regards 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 [19]. WHO does not directly consider electrical conductivity in guide lines in drinking water quality, but it does not give recommendations for dissolved solid because of taste consideration [19]. Turbidity values ranged between 2-70 NTU and 15.9 NTU which exceeded WHO permissible limit. Only water sample from E2, E6, E8 and E9 showed the values (2, 2, 2 and 3) respectively which falls within WHO permissible limit. Turbidity measures the degree to which water loses its transparency due to suspended particles [26]. High turbidity protect microorganism from effect of disinfection thereby can stimulates bacterial growth [31, 32]. According to Langenegger (1994), 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 is less acceptable to consumer from aesthetic view point [19]. The range of total hardness is 30-280mg/L and the mean is 142 mg/L which exceeded the WHO standards of drinking water quality. Only water from four sampling point namely: E1, E3, E5, E6 showed the values 210,275,280 and 185 respectively, which are above the WHO permissible limits. Hardness refers to total concentration of calcium and magnesium in water, it also measure the capacity of water to precipitates soap [26]. The range of chloride analyzed is 25 – 190mg/L and the mean is 92.495mg/L. which is below the WHO permissible limits. Chloride is usually found in form of salt of sodium, potassium and calcium (NaCl, KCl and $CaCl_2$) [26]. However chloride in excess of about 250mg/L can give raise to detectable taste in water [33]. The total dissolved solid values were ranged from 80-519 mg/L and the mean is 223.6 mg/L which falls within WHO permissible limits. Only water sample from E3 with the value 515 mg/L exceeded the WHO permissible limits. Ground water with TDS value<600 mg/L (electrical conductivity of about 850 µs/cm is considered good) while ground water with TDS>1200ms/cm (electrical conductivity of about 1700.00 ms/cm) becomes progressively less portable. The calcium values ranged from 12-89 mg/L and the mean is 44.76 which are below the WHO permissible limits. Only water sample from E3 and E5 show the values 89 and 75.2 respectively, which exceeded the WHO permissible limit. 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 is the most important element causing hardness of water [26]. At high level (in combination with magnesium) causes incrustation on utensils and scale deposits in water heater and boiler tubing. It also reduces soap lather [34]. The range of magnesium from the analyzed water samples is 0.02 – 22.5 and the mean is 6.011 mg/L which exceeded the WHO permissible limit. Only water sample from E7 with the value 0.02 mg/L falls below WHO permissible limit. Magnesium is the major constituent of dark-coloured mineral associated with igneous rock. Sedimentary source of magnesium include carbonate and dolomite [34]. It is an element that is essential to plant and animal's nutrition. Elevated levels (in combination with calcium) can cause incrustation utensils and water heater and consume soap lather [34]. Calcium and magnesium however, are needed by the body in much large quantities and its lack in human system will lead to adverse health effect [30]. The range of copper from the analyzed water sample is 0.00-0.36 mg/L and the mean is 0.07 mg/L which falls below the WHO permissible limit. Copper is an essential element in maintaining good health. A deficiency may result in anemia, loss of pigment, and reduced growth [34, 26]. The range of chromium in the water sample is 0.00-0.03 mg/L and the mean is 0.0124 mg/L which is within the WHO permissible limit. Chromium is a naturally occurring metallic element occurring most frequently in igneous rocks. Trivalent chromium is an essential element for maintaining good health; a deficiency may result in atherosclerosis [34]. The range of nitrate from the analyzed water sample is 9.02 -221 mg/L and the mean is 58.8 mg/L which exceeded the WHO permissible. Only water sample from E2, E3 and E6 showed the values 57.01, 101.2 and 221 respectively which exceeded the WHO permissible. Concentration in ground water is usually low with elevated levels occurring in brines and thermal spring. It is an essential element for making good health. High level can stain laundry and plumbing and cause teeth problem [34]. The range values of Total coliform from the analyzed water samples were 36-176.cfu/100ml and the mean 84.3.cfu/100ml which are not safe for drinking. Coliform bacteria are used as indicators of water quality. Their presence in drinking water may indicate a possible presence of harmful disease causing Organism. Their detection in drinking water is also relatively simple and economical [26]. The range value of faecal coliform from analyzed water sample is 0-100 cfu/100ml and the mean is 37 cfu/100ml which exceeded the WHO permissible limit. Only water sample of E1 with the value 0 which falls within the WHO permissible limit. According to WHO standard no coliform should be detected at all in any 100 ml of drinking water [26].

Conclusion

The result revealed high variation between WHO, SON, NIS and NSDWQ Standards for potable water and the obtained values. The implication is that the water from most of the study area is not suitable for direct human consumption. The closeness of the source of water to dumpsites was blamed for increased levels of the parameters obtained.

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