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Water Quality Assessment of Some Hand-dug Wells in Warri, Delta State.

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Abstract

The physico-chemical and microbial properties of groundwater in selected areas in Warri was assessed. Thirteen (13) samples from hand-dug wells were analysed using AAS, titrimetric and calometric methods for the determination of cations, anions and heavy metals. From findings, all the physico-chemical parameters were within WHO permissible limit for drinking water except for colour which have values ranging between (5-8ft/co), Cadmium (0.001-0.007mg/l) and DO values (6.10-6.90mg/l). The microbial parameters, coliform bacteria(1400-2000cfu) and Escherichia coli(3000-9000cfu) were present in all the samples with the former being a reflection of the unsanitary habits of the well users and the latter showing their unfitness for domestic use without treatment. The high cadmium concentration in the area which is not unconnected to gas flaring poses as a toxin to users that depend on wells as a source of water supply in that area.

Key words: Hand-dug. Wells. Physico-chemical. Treatment. Water quality

1.0 Introduction

Quality drinking water is essential for life. Unfortunately, in many countries around the world, water has become a scarce commodity as only a small proportion of the populace has access to treated drinking water. Alternative sources of water such as rainwater and groundwater have become major sources of drinking water for people who do not have access to treated water. The need to access quality of water from some of these alternative sources of water has become imperative because they have a direct effect on the health of individuals. Groundwater perhaps constitutes the largest source of dug well water. It is located below the soil surface and is largely contained in interstices of bedrocks, sand, gravel and other interspaces through which precipitation infiltrates and percolates into the ground aquifer due to gravity[1]. The drinking qualities of dug well water are largely dependent on the concentration of biological, chemical and physical contamination[2].

Thousands of wells are being drilled each year with the goal of supplying safe and accessible drinking water. Unfortunately, many of these wells offer water which is either unsafe for human consumption and or has such poor aesthetic quality that no one can consume it.With urbanization resulting into high degree of population densities, and concentration of social-economic activities, it has become increasingly difficult to meet all water requirements both in quantity and quality. The public water system is intermittent and unreliable, thus resulting to high dependency on safe supplementary sources such as hand-dug wells, rivers, streams and ponds[3].Concerned over the quality of water harnessed especially in hand-dug wells have received wide attention among researchers [4;5]. Consistent in their findings is that water in hand-dug wells is polluted through physical, geochemical and anthropogenic activities. There is thus the need to assess the quality of groundwater from hand-dug wells in Warri and compare the physico-chemical and microbial properties with WHO guide for drinking water. This study attempts to assess the quality of the water samples from hand-dug wells and determine the potability of water for drinking purpose.

2.0 Geographical Setting

The study area is situated in Warri, Delta State and lies within latitude $5^{0}30^{\prime}$N-$5^{0}31^{\prime}30^{\prime\prime}$N and longitude $5°45^{\prime}$E-$5°46^{\prime}$E,(Figure 1). Warri is surrounded by a tropical rain forest and swamp. The area experiences high rainfall and humidity for most part of the year. The climate is equatorial and is marked by two distinct seasons; the dry season and the wet season.

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The dry season lasts from November to April and is significantly marked by the cool "Harmattan" dusty haze from the north east winds. The wet season spans May to Octoberwith a brief dry spell in August, but frequently rains even in the dry season. The area is accessible by major tarred roads and footpaths.

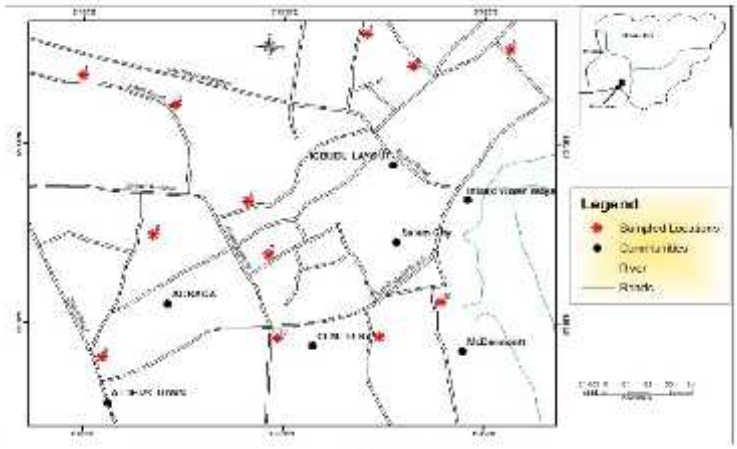

Figure 1: Showing sample location from Warri and Environs.

3.0 Geological Setting

The Niger-delta Basin is the last phase of the Benue Trough evolution which began in the Late Jurassic to Early Cretaceous. Its sedimentation began via the Paleocene transgressive episode and subsequent regression from the Late Eocene to present day. The Tertiary stratigraphy of the Modern Niger-delta comprise three (3) diachronous lithostratigraphic units viz: the Akata Shales (Paleocene-Recent) deposited in an open marine environment with thickness in excess of 1000m; the Agbada Formation (Eocene-Recent) which comprise intercalations of sands and shales deposited in a parallic environment, its thickness is in excess of 3000m; the Benin Formation (Oligocene-Recent) continental facies comprising poorly sorted sands and gravels interbedded occasionally with clays. It is the main and most productive aquifer in the Basin [6;7;8]. Its thickness is in excess of 2000m[9].This Tertiary stratigraphy is overlain (in the Southern part of the Basin) by Quartenary-Recent alluvial sands of the Sombreiro-Warri Formation which is oftentimes arkosic (with feldspar content of about 30-40%) and is also water bearing and may be gravelly and is locally associated with peat and clay lenses [9]. Its thickness ranges anywhere from 40m to 150m [10;11].The geological map of the study area comprises sandy clays (Figure 2).

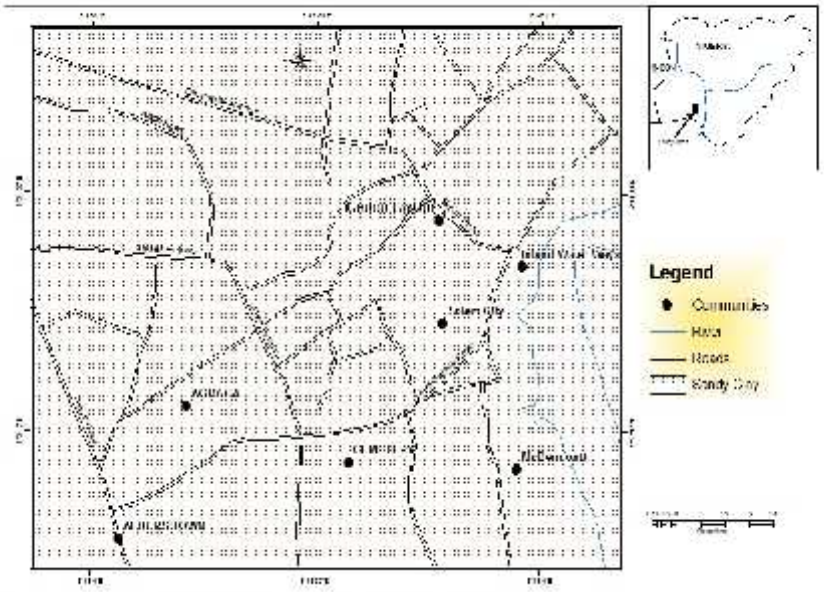

Figure 2: The geological map of the study area and Environs.

4.0 Materials and Methods

Thirteen (13) hand-dug wells were selected randomly and sampled to assess the quality of groundwater in the area. Water samples were collected into clean sterilized plastics bottles. The samples were labeled, stored in ice-bags and transported to the laboratory. Analyses of samples were carried out within 24hours after sampling. The pH meter, using a glass electrode potentiometer was used to take pH values of all samples. A spectrophotometer was used to determine the colour.

A conductivity meter was used to determine the electrical conductivity of the sampled water. The conductivity meter makes use of a measuring cell which is detached from the instrument before measurement. The measuring cell was thoroughly cleaned with a bottlebrush and rinsed with distilled water, after which it was rinsed with small amounts of the sample to be tested. The button was held down while the measuring dial pinter was slowly rotated until the balance indicator was central. The readings observed for each sample were measured in us/cm[12]**.**Iron (Fe) concentrations were determined by the use of ortho-phenophthalein for change in colour.

An AAS was used for the determination of Sodium(Na^+),Potassium(K^+), Cadmium(Cd^{2+}), Chromium(Cr^{2+}), Manganese(Mn^{2+}), Lead(Pb^{2+}) and Nickel(Ni^{2+}). A buck model Flame Atomic Absorption Spectrophometer (AAS) was used for the determination of Sodium(Na^+),Potassium (K^+), Cadmium(Cd^{2+}), Chromium(Cr^{2+}), Manganese(Mn^{2+}), Lead(Pb^{2+}) and Nickel(Ni^{2+}). The samples were aspirated into the flame and atomized. Thereafter, a standard solution for each heavy metal was prepared from the sample (in ppm) using metal salt of metals to be determined[14]. The instrument was switched ON for about 15 minutes to ramp up for stability and the required lamp for each metal was fixed. The standard of each metal was aspirated as well as the samples simultaneously. The absorbance series was then recorded under the same condition

The titrimetric method was used to determine Cl^-. 50ml of the sample was measured into a conical flask and 10 drops of potassium chromate was then added which changed the colour of water samples to yellow. The water samples were then titrated against 0.05ml of silver nitrate the titration endpoint (potassium chromate) is the change in colour from yellow to reddish brown. The chloride ion present in the water precipitated as white silver chloride[13].

Nitrate(NO_3^{2-}) was determined using phenol-sulphuric method. This involved using hydrazine sulphate ($N_2H_2.H_2SO_4$) and copper sulphate ($CuSO_4.5H_2O$) as a catalyst to obtain a reddish colour, the intensity of which was then matched with the standard Aqua Merck nitrate colour scale. The corresponding concentration was read in the scale in ppm. Phosphate(PO_4^{2-}) was determined through a method similar to the one discussed above, using the Aqua Merck water analysis reagent kit.

The multiple tube fermentation technique was used in the determination of total coliform bacteria and E.coli. The laboratory procedure include sterilization of some apparatus using autoclave, after which test samples were diluted and shaken, and 0.1ml for each sample was asceptically withdrawn and spread on nutrient agar plate. The plates where gently swirled and allowed to gel, before incubation for 2days under controlled temperature of 25-27^{0}C. Multi tube fermentation technique was used for presumptive coliform[15].Water samples was cultured in multiple fermentation tubes containing single (1ml) and double strength (10ml) MacConkey broth and subsequently incubated at 37^{0}C (for Coliform count) and 44^{0}C (for *E.* Colicount) for 24hrs and 48hrs respectively. Positive result indicated by pale yellow colouration or formation of gas was further investigated by using eosin methylene blue. The presence of E-coli in the water sample was confirmed by the presence of colonies of green metallic sheen[16].

5.0 Results and Discussion

The data containing the physical, chemical, microbial parameters and WHO[17] recommended concentration limits for drinking water are listed in Table1,2 and 3, respectively. The physical parameters in Table 1 all fall within WHO guideline for safe drinking water except for colour which had values of 6.0 in sample 2, 4, 9, 12 and 13, values of 7.0 in sample 5 and 8 and values of 8.0 in sample 6 as compared with WHO[17] recommended permissible limit of 5.0. All samples had colour higher than WHO[17] guideline for safe drinking water except sample 1 (Eburu), sample3 (Efujuku), sample7 (Maduku), sample10 (Cemetry) and sample11 (Odibo). Sample 6,(3rdMarine) had the highest amount of colour change of 8.0ft.co. Other physical parameters such as the pH, electrical conductivity and turbidity had values within WHO guidelines. The dissolved oxygen (DO) for all the samples exceeded WHO permissible limit and had values ranging from 6.10-6.90mg/l when compared to WHO limit of 4-6mg/l. The chemical parameters as shown in Table 2 all fall within WHO permissible limit except Cd, which have values as follows: sample 2(0.006mg/l), sample 3(0.005mg/l), sample 4(0.006mg/l), sample 5(0.006mg/l), sample 10(0.005mg/l), sample 11(0.004mg/l) and sample 12(0.007mg/l).These samples exceed WHO[12]maximum permissible limit of 0.003mg/l. The microbial parameters shown in Table 3 reveals the presence of coliform bacteria (1400-2000)and E.coli (3000-9000) in all the samples collected.

6.0 Conclusion

The results from this study show high change in colour which can be due to the suspension and movement of fine particles during heavy rains from top soil into the wells. The high concentration of Cd which is above WHO[17] guideline for safe drinking water might be associated with refined petroleum products, phosphate fertilizers, pigments, batteries, stabilizers for PVC in alloys, electronic compounds, as bi-products in zinc or lead products and as a result of high gas flaring in the area.

The value of dissolved oxygen which decreases with increase in temperature is a reflection of the rate at which oxygen is used up by the activities of micro-organism. The high values of coliform bacteria and E-coli reveal endemic morbidity exists in these hand-dug wells suggesting significant potential health risk to the populace. Such presence also shows significant microbial groundwater contamination. Remediation should be the introduction of microbial disinfection procedures to groundwater to improve its quality and potability.

Table 1: Physical parameters of water samples from hand dug wells in selected areas in Warri and Environs.

Sample Number / Physical parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	WHO [17]
P^H	7.9	8.4	8.1	7.8	8.0	8.2	6.8	7.7	7.6	7.5	6.9	6.8	8.0	6.5-9.5
Colour (Ft.co)	5.0	6.0	5.0	6.0	7.0	8.0	5.0	7.0	6.0	5.0	5.0	6.0	6.0	5.0
Electrical Conductivity(µs/cm)	322	440	250	310	275	490	560	246	233	438	284	351	363	900-1200
Turbidity (NTU)	2.1	4.3	3.0	2.0	4.5	3.7	2.6	3.1	4.0	3.5	2.0	2.3	3.3	5.0
Dissolved Oxygen (mg/l)	6.20	6.10	6.60	6.40	6.80	6.70	6.60	6.90	6.20	6.30	6.40	6.50	6.70	4-6
Total Dissolved Solids (mg/l)	69	78	90	98	68	11	105	95	88	80	72	84	123	500-1500
Total Suspended Solids (mg/l)	0.4	0.9	1.2	1.6	0.8	0.3	0.6	1.0	1.3	1.5	1.4	0.8	0.7	-

Table 2: Chemical parameters of water samples from hand dug wells in selected areas in Warri and Environs.

Sample Number / Chemical Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	WHO [17]
Fe^{2+}	0.200	0.102	0.100	0.201	0.110	0.200	0.213	0.111	0.215	0.211	0.234	0.202	0.221	0.30
Na^{+}	6.53	11.01	10.74	4.15	14.19	18.48	2.53	16.20	4.00	6.01	7.73	7.10	3.91	200
K^{+}	1.38	0.99	1.56	4.37	2.43	1.09	7.01	8.58	7.66	4.51	2.03	6.54	6.11	-
Mn^{2+}	0.041	0.032	0.001	0.070	0.054	0.052	0.002	0.231	0.085	0.043	0.237	0.055	0.064	0.400
Cd^{2+}	0.002	0.006	0.005	0.007	0.006	0.003	0.001	0.003	0.002	0.005	0.004	0.002	0.007	0.003
Cr^{2+}	0.03	0.01	0.02	0.04	0.01	0.02	0.01	0.04	0.03	0.02	0.02	0.04	0.03	0.05
Pb^{2+}	0.004	0.003	0.001	0.002	0.003	0.002	0.001	0.001	0.003	0.002	0.004	0.003	0.001	0.01
Ni^{2+}	0.009	0.006	0.002	0.004	0.013	0.018	0.003	0.018	0.007	0.005	0.010	0.012	0.017	0.02
Cl^{-}	19.6	21.3	20.4	16.6	11.2	10.2	8.84	9.10	12.4	14.7	13.5	17.6	18.3	200-250
NO^{3-}	0.63	0.69	0.56	0.74	0.98	0.93	0.88	0.65	0.52	0.37	0.84	0.92	0.48	10-50
SO_4^{2-}	0.38	0.27	0.18	0.29	0.58	0.16	0.29	0.43	0.55	0.13	0.19	0.28	0.60	250-500
PO_4^{2-}	0.053	0.048	0.063	0.075	0.041	0.032	0.044	0.069	0.078	0.093	0.063	0.055	0.040	-

Table 3: Microbial parameters of water samples from hand dug wells in selected areas in Warri and Environs.

Sample number / Microbial parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	WHO [17]
Coliform Bacteria	1600	1900	1500	1600	1400	1500	1700	1900	2000	1800	1700	1600	1500	-
E.coli	6000	5000	7000	8000	6000	7000	5000	4000	6000	7000	9000	4000	3000	-

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