PUBLISHED WORK ON HAND DUG WELL 1

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Evaluating the Constituents Concentration of Contaminants in Hand-dug Wells in Onne Southeastern Nigeria

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Abstract

The study focused on evaluating the constituents concentration of contaminants in hand-dug wells in Onne southeastern Nigeria evaluate the constituents' concentration of contaminants in hand-dug wells in Onne southeastern Nigeria and ascertain its seasonal variations (Dry and Wet). *The study adopted standard method to determine the concentration of associated water quality parameters analyzed in accordance with standard methods of (APHA 1998) including pH, Electrical conductivity, Total dissolved solid, Turbidity, Total Chloride, Total Alkalinity, Total hardness, Nitrate, Sulphate, Phophate, Bicarbonate, Calcium, Soldium, Potassium, Total cyanide, Copper, Lead, Cadmium, Chromium, Mercury, Nickel, Arsenic, Betex, Total Petroleum Hydrocarbon, oil and Grease, Vanadium, Zinc, Selenium, Total iron and Magnesium. From the results obtained, the concentration of Na, Mg, Ca and Zn were lower than the limit set by regulatory body for drinking water in all the seasons. The concentration of Cl, Cu, Pb, Cd, As, Hg, Ni, V, and Se during the dry season were not in conformity with the 2006 established standard limit for safe drinking water. For the wet season, it was revealed that the pH of Cl, Cu, Pb, Cd, As, Hg, Ni, and Se were also not in conformity with regulatory standards. Additionally, from the values of 0.768 and 0.770 obtained for the Pollution Index for Onne hand dug well covering dry and wet seasons, this study recommended further treatment of the water for human consumption.*

Keywords: Contaminant, Concentration, Hand-dug, Wells, Onne.

Introduction

Every human being is entitled to portable drinking water. Fresh water is already a limiting resource in many parts of the world [1]. In the next century, it will become even more limiting due to increased population, urbanization and climate change [2]. Therefore, all hands should on deck to forestall what can better be referred to as "water crisis". In the world of so many rivers, stream, seas and oceans access to safe drinking water most especially in the sub-Sahara Africa and the southeastern part of Nigeria is a still a far cry. Groundwater contamination arising from several pollution point sources through runoffs and underground migration pathways are major channels through which hand dug wells receive different loathsome contaminants. Effluent from industries, waste dumps, construction sites and acidic precipitation find their way into underground water and surface water bodies leading to severe concentration of contaminants in water wells most especially the hand-dug wells relied upon by the masses. With the indiscriminate dumping of refuse and other poisonous substances along roadside which are always higher than the places where hand–dug wells are located create the easy transportation of contaminants into the groundwater.

Onne is located in the Niger Delta region of Nigeria. It is a very important commercial hub in Eleme Local Government Area of Rivers State. In Onne, people still rely strongly on hand dug well even when they have bore hole facility. This reliance on hand dug well is not unconnected with the incessant power outage in the area as only very privileged few can afford to power their water pumping machines with generators.

Therefore, while they wait for the electricity distribution company to restore power which may not be available for days running to weeks and months, the hand dug well becomes a ready alternative source of water for both agricultural and domestic consumption.

Ground Water (boreholes, hand dug wells) is an important source of drinking water in both Onne and environs because of certain properties not possessed by surface water [3-4]. More than 50% of the world population relies on groundwater for their daily activities and survival. Every sector of the economy across the globe depends on groundwater as either a minor or a major raw material for their production process. The main focus in the demand for groundwater is its quality. Determination of water quality is one of the most important aspects in studies [5-7]. Moreover, the availability of portable water for the resident of the Niger Delta has become worrisome due the vulnerability of the water resources to contamination. The level of sustainability of groundwater quality is also a grave concern. The neglect of rural areas in most developing countries in terms of basic infrastructures such as pipe-borne water and sanitation facilities, expose the villages to variety of health related problems such as water-borne diseases [8]. The consumption of groundwater from contaminated aquifers has severe health implication. It is in light of this that this study seeks to evaluate the contaminants as it affects the hand-dug wells in Onne and to delineate the concentration levels of the existing parameters.

Materials and method

Sample collection

Sampling points were chosen for hand dug well. The sampling points for hand dug well are; Location 1 (Okirika), location 2 (Onne Wharf), location 3 (Ogu area), location 4 (Control) as shown in (Figure 1).

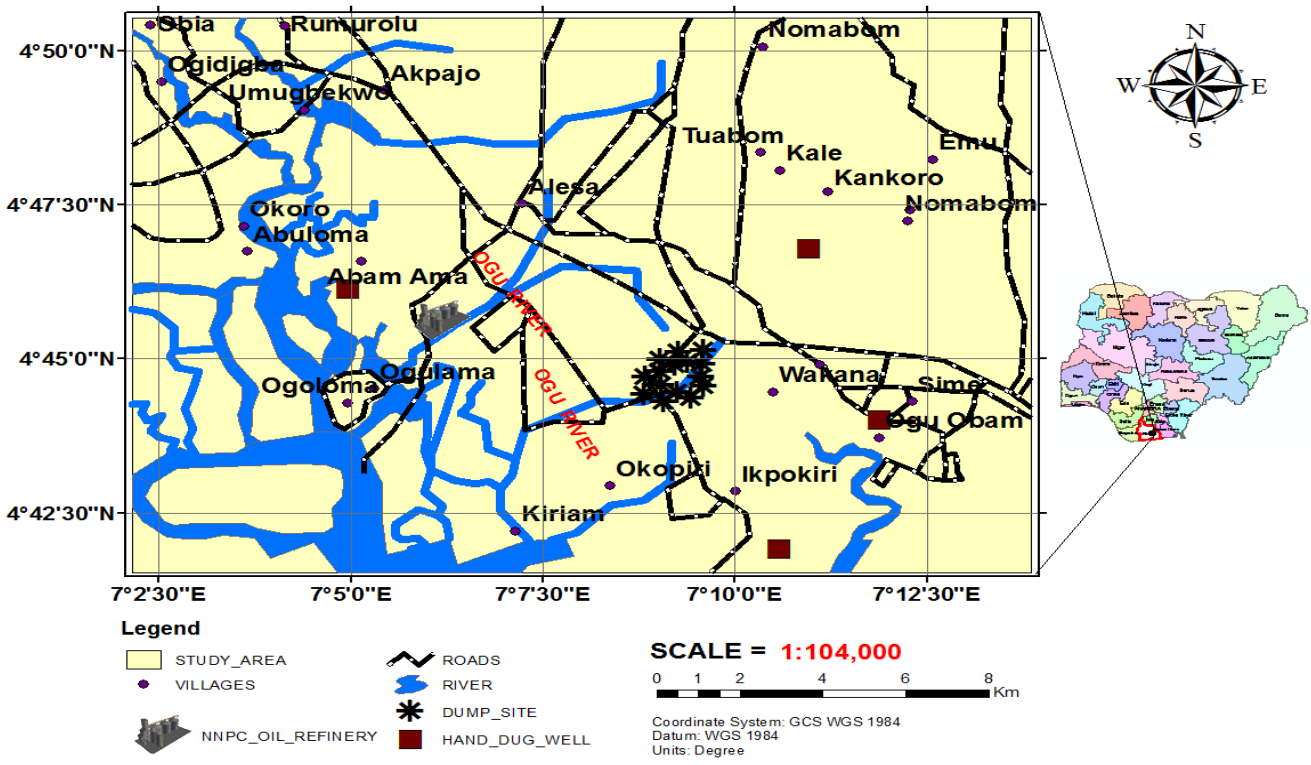

Figure 1: Location map showing hand dug well sample points

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Sampling Procedures

Sampling was carried out in the months of December, January and February to represent dry season and the months of May, June and July to represent rainy season. The samples collected from various strategic locations covered industrial, commercial and residential areas. Four hand-dug well samples were collected at Okrika, Onne wharf area and River Ogu area and a control from a distant community. Water samples were collected in well labelled polyethylene containers that had earlier been sterilized with acidified water. Immediately after collection, the samples were carefully corked under water to avoid contact with air. The water samples were taken to the laboratory and stored at 4°C in a refrigerator prior to chemical analysis. Water quality parameters analyzed in accordance with standard methods of [9] were pH, Electrical conductivity, Total dissolved solid, Turbidity, Total Chloride, Total Alkalinity, Total hardness, Nitrate, Sulphate, Phophate, Bicarbonate, Calcium, Soldium, Potassium, Total cyanide, Copper, Lead, Cadmium, Chromium, Mercury, Nickel, Arsenic, Betex, Total Petroleum Hydrocarbon, oil and Grease, Vanadium, Zinc, Selenium, Total iron and Magnesium.

Quality Assurance Procedure

Precautions were seriously taken in the course of sampling and analysis of trace elements. Also, before the commencement of sample collection, the sample containers were soaked overnight in 2% nitric acid and washed with double distilled water. All the samples were collected in polythene containers.

Results and discussion

The results of the physical and chemical characteristics of Onne hand – dug wells during the dry season is presented in Table 1 while that of the wet season is in Table 2. Figure 2 shows hand dug well mean seasonal comparison of pH. Figure 3 shows the seasonal comparison of major cations and anions (Ca, Mg, Na, K, Cl, HCO_3, SO_4, and NO_3 respectively). Figure 4 shows the seasonal concentration comparison of each heavy metals (Cu, Hg, Pb, Zn, Cd, As, Cn, Cr, V, and Se respectively). Table 3 shows Pollution Index for Onne hand dug well for dry and wet Seasons.

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Table 1: Physiochemical Properties of Onne Hand Dug Wells (Dry Season)

Parameters	Sample Location 1 (Okirika)	Sample Location 2 (Onne Wharf)	Sample Location 3 (Ogu)	Mean	Control Point	FME Standard (2006)
Co-ordinates	N 4^0 46.095^l	N 4^0 41.912^l	N 4^0 43.977^l		N 4^0 32.313^l	
	E 7^0 4.969^l	E 7^0 10.575^l	E 7^0 11.844^l		E 7^0 7.145^l	
Elevation, m	12.19	13.00	12.50		16.5	
pH @ 25^0C	5.67	5.68	5.66	5.67	6.50	6.50 - 8.50
Electrical Conductivity(µS/ cm)	10,00	11.00	10.50	10.50	8.50	1000
Total Dissolved Solids (TDS), mg/l	6.00	6.60	6.3	6.30	6.10	500
Turbidity, NTU	10.00	9.20	9.50	9.56	6.40	10.00
Total Chloride ,mg/l Cl	251.000	252.00	254.88	252.62	220.00	250
Total Alkalinity, .40mg/l	9.50	9.20	8.80	9.16	11.40	-
Total Hardness, mg/lCaCO$_3$	12.00	11,50	11,00	11.50	10.60	200
Nitrate, mg/l	41.17	42.00	38.50	40.56	22.40	50.00
Sulphate, mg/l	13.63	13.23	13.34	13.40	10.80	200-400
Phosphate, mg/	0.41	0.44	0.30	0.383	0.20	<5.00
Bicarbonate, mg/l HCO_3^-	64.00	63.42	60.00	62.47	50.00	-
Calcium, mg/l Ca	5.50	5.20	4.60	5.10	3.00	200
Sodium, mg/l Na	162.73	161.00	163.80	162.51	158.00	200
Potassium, mg/l k	20.00	21.50	18.60	20.03	15.50	-
Total Cyanide, mg/l Cn	ND	ND	ND	0	ND	0.01

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Copper, mg/l Cu	0.054	0.050	0.060	0.234	0.03	0.05
Lead, mg/l Pb	0.122	0.130	0.120	0.124	0.100	0.01
Ca dmium, mg/l Cd	0.161	0.164	0.160	0.161	0.140	0.05
Chromium, mg/l Cr	0.032	0.034	0.034	0.033	0.02	0.05
Mercury, mg/l Hg	0.031	0.034	0.030	0.031	0.026	0.001
Nickel, mg/l Ni	0.069	0.070	0.072	0.070	0.06	0.05
Arsenic, mg/l As	0.226	0.220	0.218	0.221	0.200	0.20
BETEX, mg/l	0.004	0.005	0.004	0.004		
Total Petroleum Hydrocarbon, mg/l	ND	ND	ND	0	ND	NS
Oil and Grease, mg/l	ND	ND	ND	0	ND	0.003
Vanadium, mg/l V	0.06	0.04	0.04	0.046	0.03	0.05
Zinc, mg/l Zn	0.475	0.450	0.480	0.460	0.400	3.00
Selenium, mg/l Se	0.18	0.16	0.14	0.16	0.06	0.05
Total iron, mg/	0,03	0.02	0.03	0.026	0.01	0.03
Magnesium, mg/l Mg	1.52	1.50	1.48	1.50	1.30	

FME= Federal Ministry of Environment

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Table 2: Physiochemical Properties of Onne Hand Dug Wells (Wet Season)

Parameters	Sample Location 1 (Okirika)	Sample Location 2 (Onne Wharf)	Sample Location 3 (Ogu)	Mean	Control Point	FME Standard (2006)
Coordinates	N 4^0 46.095^l	N 4^0 41.912^l	N 4^0 43.977^l		N 4^0 32.313^l	
	E 7^0 4.969^l	E 7^0 10.575^l	E 7^0 11.844^l		E 7^0 7.145^l	
Elevation, m	12.19	13.00	12.50		16.5	
pH @ 25^0C	5.70	5.76	5.70	5.72	6.50	8.50
Electrical Conductivity(µS/cm)	11.80	11.60	10.80	11.40	9.50	1000
Total Dissolved Solids (TDS), mg/l	5.66	5.62	6.14	5.80	5.50	500
Turbidity, NTU	12.00	9.40	9.80	10.40	6.60	10.00
Total Chloride ,mg/l Cl	254.00	253.00	252.68	253.22	230.50	250.00
Total Alkalinity, mg/l	9.80	9.40	9.00	9.40	11.60	-
Total Hardness, mg/l$CaCO_3$	12.20	11.80	11,40	11.80	10.80	200
Nitrate, mg/l	42.80	42.60	38.80	41.40	22.40	50.00
Sulphate, mg/l	13.68	13.26	13.38	13.44	10.00	200-400
Phosphate, mg/	0.44	0.48	0.33	0.41	0.20	<5.00
Bicarbonate, mg/l HCO_3^-	64.12	64.04	62.00	63.38	48.00	-
Calcium, mg/l Ca	5.52	5.60	4.80	5.30	3.20	200

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Sodium, mg/l Na	164.74	164.40	165.84	164.99	152.42	200
Potassium, mg/l k	20.00	21.50	20.60	20.70	15.50	NS-
Total Cyanide, mg/l Cn	ND	ND	ND	0	ND	0.01
Copper, mg/l Cu	0.434	0.429	0.430	0.431	0.04	0.05
Lead, mg/l Pb	0.124	0.160	0.140	0.141	0.104	0.01
Cadmium, mg/l Cd	0.164	0.166	0.162	0.163	0.144	0.05
Chromium, mg/l Cr	0.034	0.038	0.06	0.044	0.02	0.05
Mercury, mg/l Hg	0.034	0.036	0.033	0.034	0.028	0.001
Nickel, mg/l Ni	0.071	0.076	0.074	0.074	0.07	0.05
Arsenic, mg/l As	0.228	0.222	0.228	0.225	0.202	0.20
BETEX, mg/l	0.005	0.006	0.005	0.0053	0.001	NS
Total Petroleum Hydrocarbon, mg/l	ND	ND	ND	0	ND	NS
Oil and Grease, mg/l	0.001	0.001	0.002	0.0013	ND	0.003
Vanadium, mg/l V	0.07	0.05	0.04	0.053	0.02	0.05
Zinc, mg/l Zn	0.478	0.460	0.484	0.474	0.404	3.00
Selenium, mg/l Se	0.26	0.20	0.18	0.213	0.09	0.05
Total iron, mg/l Fe	0.04	0.03	0.03	0.03	0.01	0.03
Magnesium, mg/l Mg	1.64	1.62	1.60	1.63	1.50	

FME= Federal Ministry of Environment

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Table 3. Pollution Index for Onne Hand Dug well, Dry and Wet Seasons

		Dry Season		Wet Season	
Parameters	**Lij (WHO)**	**Cij**	**Cij/Lij**	**Cij**	**Cij/Lij**
pH	6.5	5.67	0.872	5.72	0.880
TDS	500	6.30	0.012	5.80	0.012
Total Alkalinity	100	9.16	0.091	9.40	0.094
Sulphate	400	13.40	0.033	13.44	0.034
Chloride	250	252.62	1.010	253.22	1.012
Total Cij/Lij			**2.018**		**2.032**
Mean Cij/Lij			**0.4036**		**0.4064**
Max Cij/Lij			**1.010**		**1.012**
PI			**0.768**		**0.770**

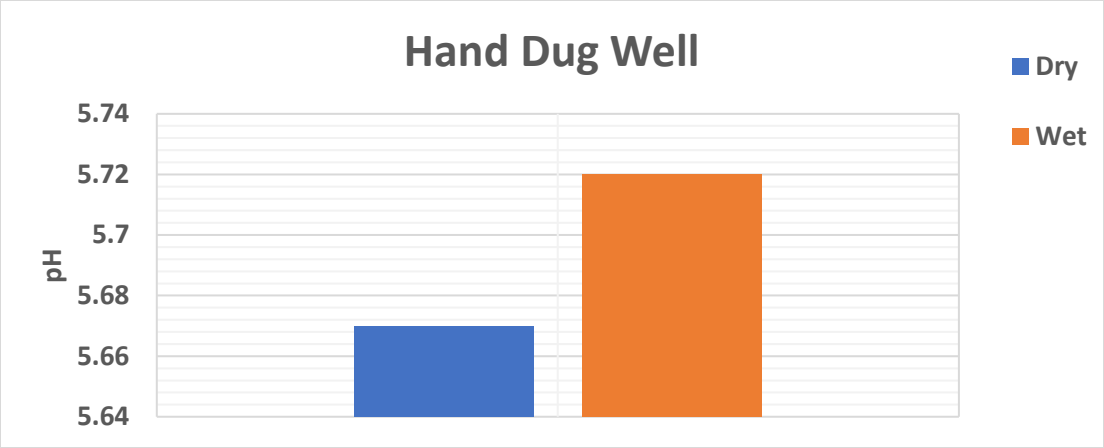

Figure 2: Hand dug well mean seasonal pH comparison

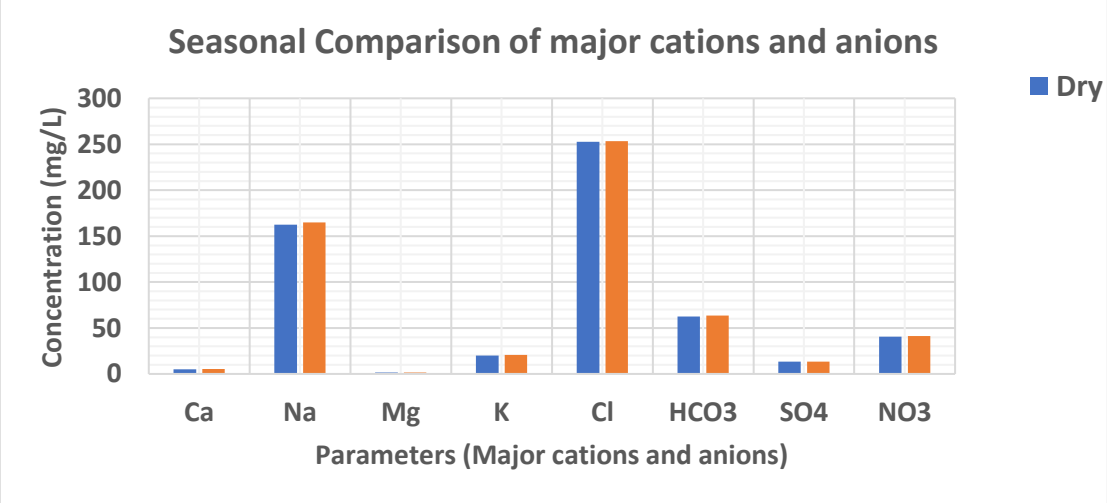

Figure 3: Hand dug well Mean Seasonal Comparison of major cations and anions

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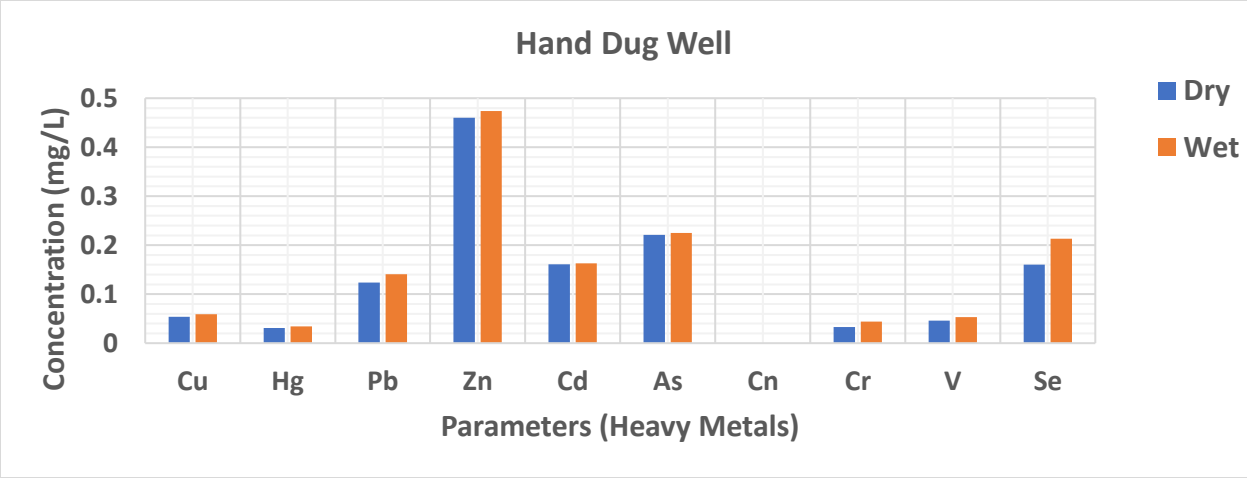

Figure 4: Hand dug well seasonal comparison of heavy metals

The study revealed a higher pH ranging from 5.66 to 5.68 and a mean value of 5.67 during the dry season while a range of 5.70 to 5.76 with a mean value 5.72 was obtained during the wet season indicating a slightly higher value than the Federal ministry of environment 2006 standard. The electrical conductivity values obtained for both dry and wet seasons fall sharply below the federal ministry of environment 2006 standard.

Nitrate and turbidity levels were within the limits of the FME standard in some cases but respectively above 10 mg/L and 5.0 NTU but sulphates, phosphates and solids were completely within the acceptable range. Turbidity (NTU) is the reduction of transparency caused as a result of the presence of particulate matters such as silt, clay, finely divided organic matter, plankton or other microscopic organisms. The colloidal materials provide adsorption sites for chemicals that may be harmful to health or cause undesirable tastes or odours. High turbidity levels are therefore associated with poor water quality. Turbidity and nitrate total chloride (Cl) values falls below the FME 2006 standard. The values recorded for total dissolved solids (TDS) from all the sample locations are far lower than the FME standard. The values recorded for Nitrate concentration ranges from 38.50mg/l to 42.17mg/l with a mean value of 40.56mg/l while the FME 2006 standard is 50.00mg/l. This implies a slightly low nitrate concentration but may also require necessary attention to avoid further increase in concentration. Calcium is the fifth most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body is stored in the bone and teeth. The high deficiency of calcium in human may cause rickets, poor blood clothing, bone fracture, etc. and the exceeding limit of calcium produced cardiovascular diseases.

According to FME (2006) standard its permissible range in drinking water is 200mg/L. However, an adult requires 100mg/day to work properly. The concentration of calcium from this study ranges in ascending order from location 3 (Ogu waterside) 4.60mg/l to location 2 (Onne wharf) 5.20mg/l and to location 1 (Okirika) 5.50mg/l during the dry season while the wet season records a different trend i.e location 3< location 1< location 2. The calcium concentration is far below the FME 2006 standard. Sodium (Na) is a silver white metallic element and found in less quantity in water. Proper quantity of sodium in human body protects many fatal diseases like kidney damages, hypertension, headache etc. The findings of this study show that sodium concentration ranges from 161.00mg/l to 163.80mg/l with a mean value of 162.51mg/l which lower than the FME 2006 standard of 200mg/l. Even though the value of sodium is lower it could still be harmful for the health of local inhabitants. From the results, it is discovered that most of the heavy metals (Cu, Pb, Cd, Cr, Hg, Ni, As, V and Se) are far higher than the limit of the FME 2006 standard in both dry and wet seasons. Elevated heavy metal concentration in this study is as a result of anthropogenic influences such as small scale industrial activities, automobile repair workshops, runoff from waste dump, arbitrary dumping of poisonous substances along roadsides and automobile emissions. The mechanisms of heavy

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metal emission from vehicles consist of fuel consumption, engine oil consumption, tire wear, brake wear, and road abrasion [10-12]. Engine oil consumption is responsible for the largest emission for Cd, tire wear contributes the most important emission for Zn, and brake wear is the most important source of emissions for Cu and Pb [10].
The study also shows higher heavy metal concentration during the wet season. This is as a result of acidic precipitation and other contaminants transported through runoffs into the groundwater.

Mean dry and wet comparison (Figures 2 to 4) of pH, Major Cations and Anions and Heavy Metals for Onne hand dug well. The hand dug well is slightly acidic from the pH values shown in the plot below. However, there is a slight increase in the pH in the wet season, 6.4as against 6.2 for the dry season.
The mean values for Ca, Na, Mg, K, Cl, HCO_3, SO_4 and NO_3 were 5.10, 162.51, 1.50, 20.03, 252.62, 13.40, and 40.56 mg/L respectively for the dry season while the mean values for Ca, Na, Mg, K, Cl, HCO_3, SO_4 and NO_3 were 5.30, 164.99, 1.63, 20.70, 253.22, 63.38, 13.44 and 41.40 mg/L respectively for the wet season. The major cations and anions also varies slightly within the seasons under study. The mean values for the heavy metals Cu, Hg, Pb, Zn, Cd, As, Cr, V, and Se were 0.234, 0.031, 0.124, 0.460, 0.161, 0.221, 0.033, 0.046, and 0.16 mg/L respectively for the dry season while the mean values for the heavy metals Cu, Hg, Pb, Zn, Cd, As, Cr, V, and Se were 0.431, 0.034, 0.141, 0.474, 0.163, 0.225, 0.044, 0.053 and 0.213 mg/L respectively for the wet season. Copernicium (Cn) although tested for, was not detected in the samples for both seasons. The heavy metals concentrations are generally slightly higher in the wet season. The following parameters; pH, Cl, Cu, Pb, Cd, As, Hg, Ni, V, and Se for the dry season were not in conformity with the Federal Ministry of Environment (FME) 2006 standards of safe drinking water while for the wet season; pH, Cl, Cu, Pb, Cd, As, Hg, Ni, and Se were not in conformity with FME standards.
The pollution index (PI) values were 0.768 and 0.770 respectively (Table 3). The critical value of pollution index (PI) is 1. This implies that any water sample greater than 1 requires treatment. Thus, the PI of the water samples is less than 1 (i.e. not critical). However, predisposal treatment should still be carried out to further reduce the PI. The pollution index of the water samples is shown in Table 3 above.

Conclusion

Evaluating the constituents concentration of contaminants in hand-dug sells in Onne southeastern Nigeria is presented. Hand dug well samples were taken from location 1 (Okirika), location 2 (Onne wharf), location 3 (Ogu) and a control point in Onne, Eleme local government of Rivers State southeastern Nigeria in during dry and wet season in 2018-2019 for constituents' concentration different contaminants (pH, cations, anions, heavy metals). The concentrations of Na, Mg, Ca and Zn were lower than FME limit for drinking water in all the seasons. The concentration of Cl, Cu, Pb, Cd, As, Hg, Ni, V, and Se during the dry season were not in conformity with the FME 2006 standards of safe drinking water while for the wet season; pH, Cl, Cu, Pb, Cd, As, Hg, Ni, and Se were also not in conformity with FME standards. More so, the pollution index obtained in this depict values that are approximate of the critical of value of unity. Based on these results, the study recommends predisposal treatment of water sample for human consumption in the study area.

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