PHYSICO-CHEMICAL AND BACTERIALOGICAL ANALYSIS OF SHALLOW HAND-DUG WELL WATER IN ISOKO NORTH LOCAL GOVERNMENT AREA, DELTA STATE

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ABSTRACT:*The study is aimed at assessing the quality of water from shallow hand-dug wells in Isoko North Local Government Area of Delta State from the month of September to November, 2015. The populace in the study area highly depends on this source of water for drinking and domestic activities. Water samples were collected from nine sites (W1, W2, W3, W4, W5, W6, W7, W8 & W9) from the study area. These samples were examined for heavy metal concentration using Atomic Absorption Spectrophotometer (AAS), bacteriological contamination and some physicochemical parameters. The results obtained were studied and compared with World Health Organization standard. The pH values obtained ranged from 4.22 to 6.08 showing that the water samples were slightly acidic. COD, DO and BOD values obtained all exceeded the permissible limit of WHO standard showing that the water from the study area may cause detrimental effect to human life. Phosphates (15.84±5.70 – 17.87±5.20) and sulphates (520.02±91.69 – 544.18±96.26) contents were higher than the WHO permissible limit. The microbiological analysis showed that the total coliform and E.Coli count recorded values were not within WHO permissible limit which is an indication of faecal contamination. All other physic-chemical parameters (temperature (28.11±0.72 – 28.30±0.59), electrical conductivity (21.36±23.24 – 25.31±23.30), nitrate (5.73±0.93 – 5.86±0.98) and chloride (61.78±10.95 – 67.11±13.84)were within the acceptable WHO (2011) Permissible limits. The water samples from the wells had higher level of heavy metals. Mn (0.08±0.05 – 0.30±0.33), Fe (0.19±0.22 – 0.32±0.34), Zn (0.33±0.19 – 0.37±0.20), Cd (0.15±0.20 – 0.20±0.29), and Pb (0.19±0.24 – 0.19±0.32) were found to be above the permissible limits of WHO specifications of 0.1 mg/l, 5mg/l, 0.5mg/l, 0.05mg/l and 0.05 mg/l for Mn, Fe, Zn, Cd and Pb respectively except for Cr which was only detected in W6. The results obtained showed that the water from the study area were contaminated/polluted making the water unfit for drinking and other domestic uses. Contamination of this water source may have been caused by closeness of water source to pit latrine, domestic refuse dumps, stagnant water, bad sewage system and other human activities. Consequently, these ground water sources in thes study require treatment before they will be good for human consumption.*

Keywords: Shallow hand-dug well water, Physico-chemical, Bacterialogical, Isoko north, Delta state.

INTRODUCTION

Water is important constituent of biotic community serving as a source of life for man, plants and other forms of life (Narayanan, 2007). It is essential for the wellbeing of mankind and for sustainable development. 97% of the total volume of water available is in the Oceans, 2% stored in the form of ice-sleets and less than 1% is available as fresh water (Narayanan, 2007). Its many uses include drinking, domestic uses, industrial cooling, power generation, agriculture (irrigation), transportation and waste disposal (Rao, 2006).

The main sources of water available to mankind are: atmospheric water, surface water (including rivers, stream, ponds, etc) and ground water (boreholes, hand-dug wells etc.). For most communities, the most secure source of safe drinking water is pipe-borne water from municipal water treatment plants. Often, most of water treatment facilities do not deliver or fail to meet the water requirements of the served community; due to corruption, lack of maintenance or increased population. The scarcity of piped water has made communities to find alternative sources of water: groundwater sources being a ready source.

Ground water constitutes 20% of water present as freshwater. The value of groundwater lies not only in its wide spread occurrence and availability but also in its consistent good quality, which makes it an ideal supply for drinking water. However, ground water resources are under serious threat due to growing interest in mechanized agricultural practices, increasing population density and rapid urbanization as well as effluent discharge from industries and healthcare centers. Groundwater provisions are sometimes unsustainable because of poor water productivity of its sources, drying of shallow dug wells after prolonged drought and sometimes due to poor water quality. In spite of all this, groundwater exploitation is generally considered as the only realistic option for meeting dispersed rural water demand (MacDonald, et al., 2005). The inability of governments to meet the ever-increasing water demand has lead to resorting to groundwater sources such as shallow wells and boreholes as alternative water resources (LAWM, 2000). Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies (Zaman, 2002) but recent development and research reports confirm that groundwater sources including shallow dug wells could equally be contaminated. Also the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata (Veslind, 1993). The presence of poorly designed pit latrines, poor solid water management as well as poor inadequate water protection, may lead to contamination of this water source with pathogenic bacteria.

The lack of safe drinking water and adequate sanitation measures lead to a number of diseases (WHO, 2004a) such as cholera, dysentery, and typhoid, and every year millions of lives are claimed in developing countries. Diarrhea is the major cause for death of more than 2 million people per year world-wide, mostly children under the age of five. It is a symptom of infection or the result of a combination of a variety of enteric pathogens (WHO, 2004). Thus, access to safe clean water and adequate sanitation is a fundamental right and a condition for basic health (WHO, 1998).

To protect the health of people and to reduce to the barest minimum of ugly experiences of drinking and/or using of low quality waters, it is necessary that the quality of water obtained from groundwater sources should be monitored with the view to finding lasting solution to health problems associated with the use and drinking of low quality waters. In this study, the use of physicochemical and biological properties of water will be used to assess the quality of water.

BACKGROUND OF STUDY

It has been observed that people use water from sources that are readily available or relatively cheap not necessarily minding the quality. Wells are common groundwater source readily explored to meet community water requirement or make up the short fall. This is the situation in many parts of Nigeria and several other African countries (Adelekan, 2010). These wells serve as major source of water for household uses (drinking, cooking, washing etc). Shallow wells provide cheap and low technology solution to the challenges of rural and urban water supply and are normally located in valleys where the groundwater table is relatively high (1 – 4m below ground level) and infiltration of rain and river water plays main part in the groundwater recharge. Shallow wells could be protected, unprotected or semi-protected. The quality of groundwater resource especially shallow well depend largely on the management of human waste as well as the natural physic-chemical characteristics of the catchments areas (Efe et al., 2005, Saba and Baba, 2004). Groundwater sources are being increasingly used as drinking water, without testing to see whether the water is of good quality. Although, it is true that soil generally function to reduce the effect of micro-organisms by a simple filtration mechanism of larger bacteria and protozoa in groundwater: pollution of shallow well water by micro-organisms especially those located near septic tanks or landfills significantly do occur.

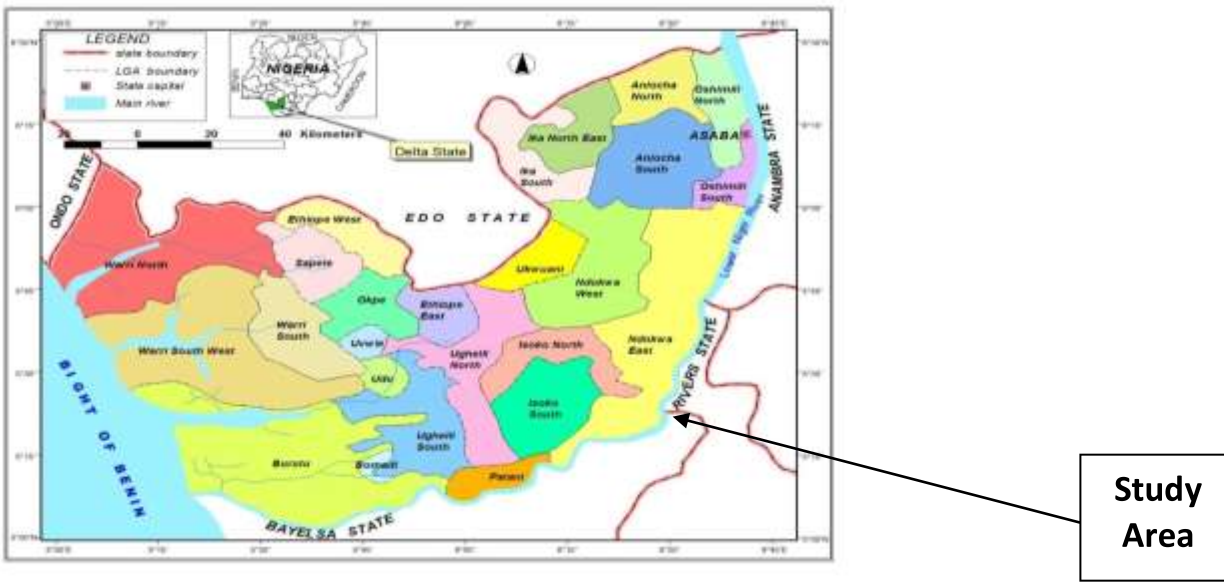

Figure 1: Map of Delta State showing the Study Area

Source: Peas Association (1992).

EXPERIMENTAL

The names of the locations of the different wells where water samples were collected for analysis are shown in Table 1.

Table 1: Sample locations and designation

Well Number	Samples Location	Coordinate points of the sample location

		(Lat/Lng)
W1	Ellu	5^{o} 59’0” N - 6^{o} 29’ 0” E
W2	Arade	5^{o} 62’ 0”N - 6^{o} 30’ 0” E
W3	Oyede	5^{o} 45’ 0” N - 6^{o} 26’0” E
W4	Ozoro	5^{o} 54’ 0”N – 6^{o} 22’0” E
W5	Owhelogbo	5^{o} 59’ 0”N - 6^{o} 19’ 0” E
W6	Emevor	5^{o} 58’ 0” N - 6^{o} 19’0” E
W7	Okpe-Isoko	5^{o} 50’ 0” N - 6^{o} 33’ 0” E
W8	Ofagbe	5^{o} 56’ 0” N - 6^{o} 35’ 0” E
W9	Iyede	5^{o} 45’ 0” N - 6^{o} 26’ 0”E

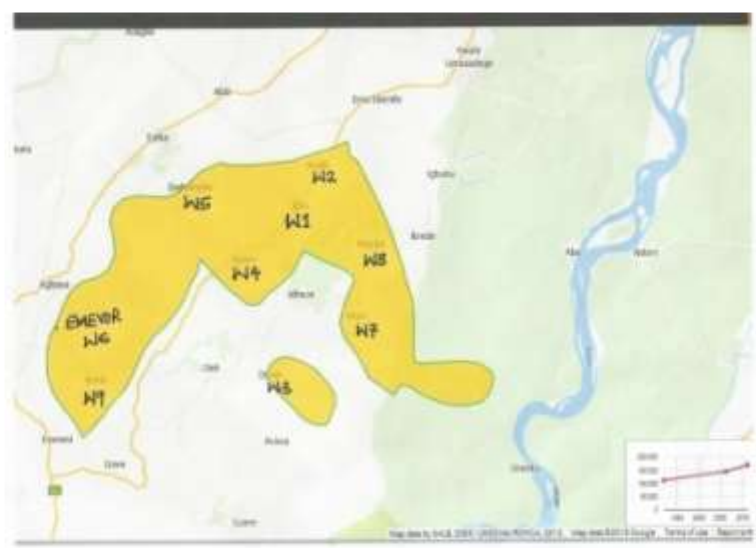

Figure 2 Map Showing Sample collection point
Source: Nigeria Population Commission (1999)

SAMPLE COLLECTION, PRESERVATION AND PRE-TREATMENT

Water samples were randomly collected from nine different sources (Shallow hand-dug wells), namely W1 (Ellu), W2 (Arade), W3 (Oyede), W4 (Ozoro), W5 (Owhelogbo), W6 (Emevor), W7 (Okpe-Isoko), W8 (Ofagbe) and W9 (Iyede) which make up the Local government area. The samples were collected within the period of September, October and November, 2015. Samples were collected once every month from all designated sampling points giving a total of 27 samples in all. At each sampling site, samples were collected into 500 ml bottles pre-rinsed with dilute nitric acid and rinsed three to four times with the water samples before filling to capacity. The samples were tightly sealed to prevent contamination and gas dissolution and then labeled accordingly. Samples for dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were collected in 250cm3 bottles sealed with stoppers. One millimetre each of Winkler's solutions A and B were added to the samples on site to fix the oxygen (APHA, 1992).

The samples were stored in coolers with ice packs before transferring them to the laboratory. The water samples collected for the study were analyzed at Springboard Research Laboratory, Awka, Anambra State.

Random sampling method was used to carry out the research. This method was employed because the number of shallow wells in the study area exceeded 100 wells. The samples were subjected to various laboratory analysis using standard procedures (APHA, 1992).

Parameters such as turbidity, Total Dissolved Solids (TDS), electrical conductivity, pH, total hardness, alkalinity, acidity, phosphate, sulphate, nitrate, chloride, iron, lead, manganese, zinc, cadmium, and chromium were analyzed in the laboratory after sample was collected.

SAMPLE PREPARATION

Samples were prepared for each parameter using the standard methods of Analysis.

RESULTS AND DISCUSSION

The results obtained after the analysis are presented below in tables.

TABLE 2: THE THREE MONTHS PHYSICOCHEMICAL PARAMETERS OF THE SHALLOW WELL WATER SAMPLES FOR THREE MONTHS (SEPT. –NOV.)

Samples	Temp (°C)	pH	Turbidity (NTU)	E. Cond (μs/cm)	TDS (mg/L)	Alkalinity (mg/L)	Total Hardness (mg/L)	COD (mg/L)	DO (mg/L)	BOD (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)	SO_4 (mg/L)	Cl^- (mg/L
Sept - W1	29.00	5.87	1.00	11.60	0.02	7.50	224.00	16.00	111.90	34.45	5.16	11.86	572.81	52.0
Sept - W2	28.00	6.01	5.00	60.10	0.06	17.50	150.00	11.20	41.50	29.45	6.68	15.45	514.33	56.0
Sept - W3	27.20	5.67	1.00	9.40	0.02	17.50	204.00	19.20	23.10	46.75	6.95	13.60	595.85	87.0
Sept - W4	27.00	4.44	1.00	10.20	0.03	7.50	130.00	16.00	41.50	37.25	7.27	27.91	485.16	80.0
Sept - W5	28.00	5.26	5.00	68.20	0.05	22.50	86.00	32.80	20.80	42.85	5.14	15.23	426.31	70.0
Sept - W6	29.00	5.51	1.00	9.50	0.02	20.00	210.00	14.40	76.50	27.36	4.79	15.45	548.91	53.0
Sept - W7	28.00	4.34	1.00	14.60	0.01	12.50	152.00	16.00	25.50	33.65	4.75	20.13	577.34	62.0
Sept - W8	28.80	5.71	10.00	33.00	0.04	25.00	188.00	19.20	46.90	18.25	6.41	23.94	742.35	59.0
Sept - W9	28.00	4.34	5.00	11.20	0.01	12.50	200.20	42.40	52.90	19.45	5.57	17.30	434.54	85.0
Oct - W1	29.00	5.96	1.00	10.20	0.03	7.20	219.00	16.00	111.90	34.45	4.87	10.28	505.34	50.0
Oct - W2	28.50	5.86	1.00	55.60	0.07	19.47	143.00	11.20	41.50	29.45	5.89	13.90	504.34	53.0
Oct - W3	28.70	4.96	1.00	8.70	0.03	15.64	220.00	19.20	23.10	46.75	5.98	13.89	519.38	72.0
Oct - W4	28.20	4.49	2.00	8.80	0.03	8.39	125.00	16.00	41.50	37.25	7.39	28.48	502.45	68.0
Oct - W5	27.60	5.29	0.89	67.30	0.13	17.10	82.00	32.80	20.80	42.85	5.39	14.29	419.45	64.0
Oct - W6	28.00	5.46	0.40	9.20	0.02	15.96	236.00	14.40	76.50	27.36	4.67	14.29	526.47	50.0
Oct - W7	29.20	4.22	1.00	12.30	0.02	14.50	138.00	16.00	25.50	33.65	4.77	16.89	545.37	65.0
Oct - W8	27.50	5.68	25.00	30.00	0.03	22.01	174.00	19.20	46.90	18.25	6.80	19.47	734.89	53.0
Oct - W9	28.00	4.38	5.00	9.30	0.01	10.32	202.00	42.40	52.90	19.45	5.84	13.89	422.46	81.0
Nov - W1	27.20	5.89	0.40	12.42	0.03	7.70	200.00	19.30	98.96	29.87	4.92	9.78	524.00	47.0
Nov - W2	28.20	6.08	0.80	48.90	0.06	22.30	142.00	13.80	46.45	34.20	5.94	16.89	515.35	59.0
Nov - W3	27.40	5.88	1.00	8.91	0.03	16.30	204.00	22.40	29.90	45.22	5.88	14.29	522.45	79.0
Nov - W4	29.00	4.53	1.00	8.20	0.02	9.20	120.00	14.70	44.20	33.26	7.30	29.89	490.40	74.0
Nov - W5	28.00	5.36	1.00	72.90	0.18	19.30	80.00	30.20	24.70	40.33	5.19	13.48	422.73	66.0
Nov - W6	29.00	5.49	1.00	10.82	0.02	18.50	211.00	13.80	70.20	30.29	4.78	13.39	530.22	48.0
Nov - W7	28.02	4.39	1.00	10.82	0.03	10.40	132.00	18.70	28.60	30.16	4.24	14.39	548.89	68.0
Nov - W8	28.50	5.78	2.00	10.20	0.03	27.00	173.00	18.20	51.30	25.34	7.38	17.24	749.67	59.0
Nov - W9	27.90	4.92	5.00	9.04	0.02	12.40	210.00	43.90	50.20	24.33	6.28	13.20	406.20	83.0

TABLE 3: THE THREE MONTHS RESULTS OF THE HEAVY METALS CONCENTRATION LEVEL OF THE SHALLOW WELL WATER SAMPLES FOR THREE MONTHS (SEPT. –NOV.)

Samples	Lead	Manganese	Iron	Zinc	Chromium	Cadmium
Sept - W1	1.11	0.04	0.17	0.33	BDL	BDL
Sept - W2	0.89	0.05	0.09	0.23	BDL	0.09
Sept - W3	1.04	0.14	0.06	0.28	BDL	0.10
Sept - W4	0.86	0.10	0.21	0.46	BDL	BDL
Sept - W5	0.67	0.06	0.17	0.13	BDL	BDL
Sept - W6	1.33	0.20	1.05	0.83	0.04	0.53
Sept - W7	0.66	0.04	0.20	0.30	BDL	BDL
Sept - W8	1.01	0.05	0.11	0.39	BDL	0.80
Sept - W9	0.59	0.17	0.26	0.37	BDL	0.25
Oct - W1	1.06	0.03	0.01	0.29	BDL	BDL
Oct - W2	0.98	0.04	0.03	0.21	BDL	0.02
Oct - W3	1.27	0.11	0.04	0.27	BDL	0.03
Oct - W4	0.79	0.10	0.19	0.37	BDL	0.02
Oct - W5	0.58	0.05	0.21	0.10	BDL	BDL
Oct - W6	1.29	0.13	0.73	0.78	0.13	0.40
Oct - W7	0.59	0.03	0.19	0.32	BDL	BDL
Oct - W8	1.09	0.03	0.10	0.32	BDL	0.67
Oct - W9	0.57	0.17	0.25	0.32	BDL	0.21
Nov - W1	1.03	0.03	0.26	0.30	BDL	0.11
Nov - W2	0.87	0.28	0.01	0.29	BDL	0.02
Nov - W3	1.59	0.12	0.04	0.28	BDL	0.06

Nov - W4	0.83	0.78	0.17	0.39	BDL	BDL
Nov - W5	0.60	0.34	0.20	0.12	BDL	BDL
Nov - W6	1.09	0.19	0.82	0.80	BDL	0.31
Nov - W7	0.62	0.03	0.17	0.34	BDL	0.01
Nov - W8	1.00	0.02	0.98	0.32	BDL	0.61
Nov - W9	0.59	0.90	0.24	0.34	BDL	0.20

NOTE: BDL (Below Detection Limit)

TABLE 4. THE THREE MONTHS RESULTS OF MICROBIOLOGICAL ANALYSIS OF THE SHALLOW WELL WATER SAMPLES FOR THREE MONTHS (SEPT. –NOV.)

Samples	Total Coliform (cfu/100ml)	*E.Coli* (cfu/100ml)
Sept - W1	10.00	2.00
Sept - W2	4.00	1.00
Sept - W3	4.00	BDL
Sept - W4	10.00	2.00
Sept - W5	18.00	2.00
Sept - W6	13.00	1.00
Sept - W7	10.00	BDL
Sept - W8	17.00	3.00
Sept - W9	9.00	BDL
Oct - W1	6.00	1.00
Oct - W2	2.00	BDL
Oct - W3	1.67	BDL
Oct - W4	7.23	1.00
Oct - W5	17.00	1.00
Oct - W6	9.00	BDL

Oct - W7	7.00	BDL
Oct - W8	14.00	1.00
Oct - W9	5.00	BDL
Nov - W1	4.00	1.00
Nov - W2	2.00	BDL
Nov - W3	1.00	BDL
Nov - W4	5.00	1.00
Nov - W5	6.00	BDL
Nov - W6	2.00	BDL
Nov - W7	4.00	BDL
Nov - W8	5.33	1.00
Nov - W9	2.00	BDL

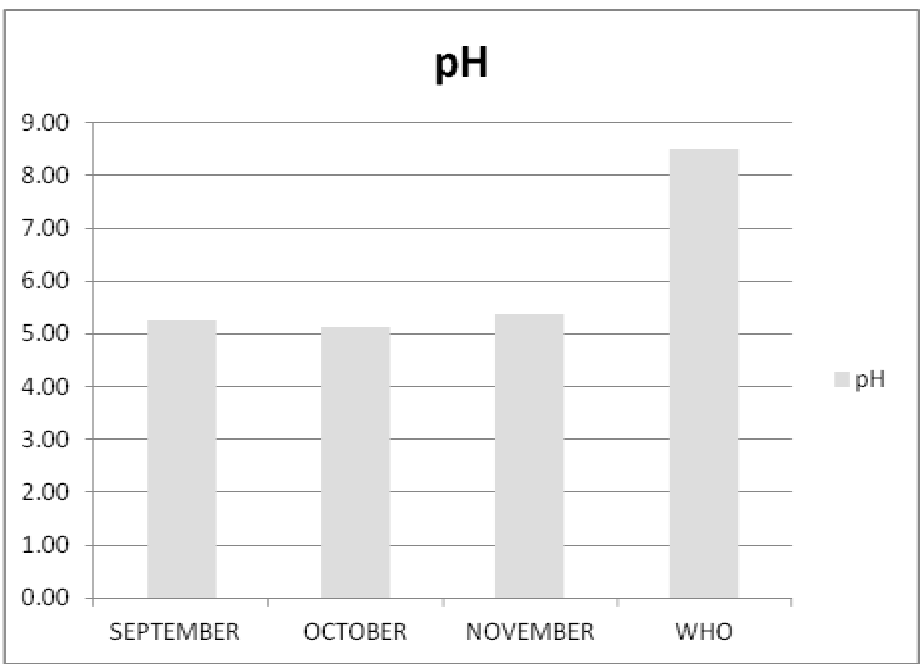

Figure 3: Graphical Representation of the Three (3) Months Mean Values of pH of the

Shallow Hand-Dug Well Water Samples

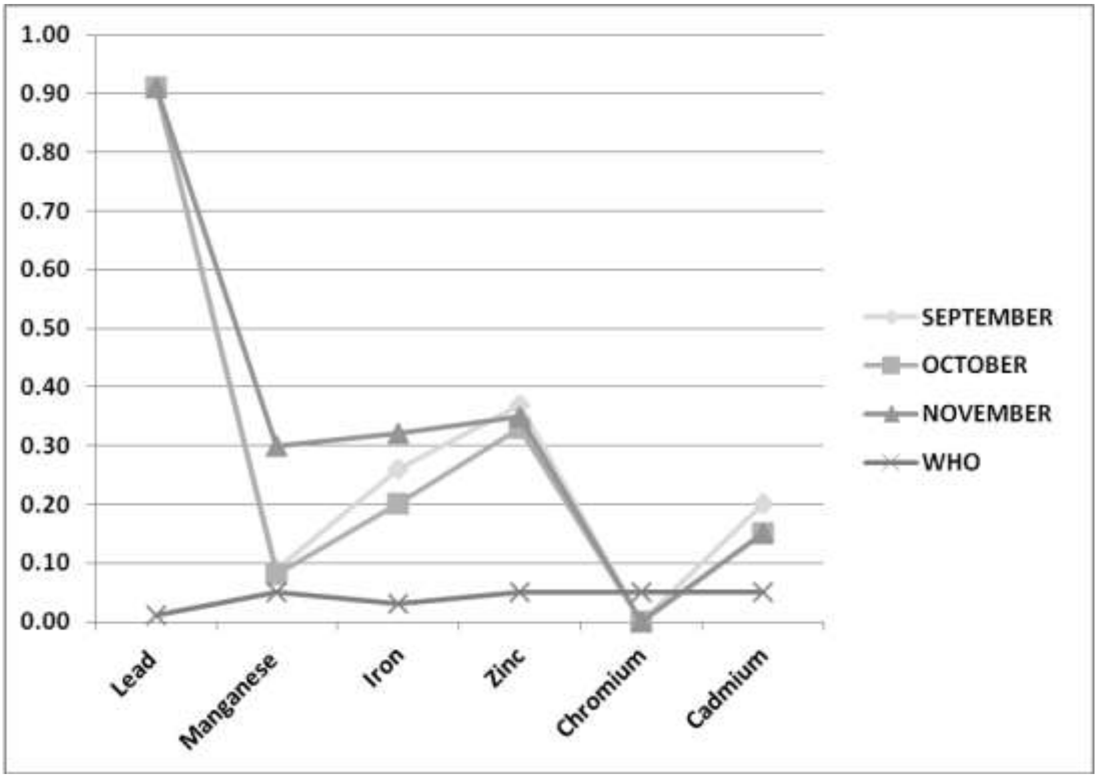

Figure4: Graphical Representation of the Three (3) Months Mean Values of the Heavy Metals concentrations in the Shallow Hand-Dug Well Water Samples.

DISCUSSION

The observed mean pH recorded in the various wells ranged from 5.14 ± 0.68 to 5.37 ±0.62 (Table 2). It exhibited acidic characteristics. These values were below the WHO (2011) recommended pH range of 6.5 to 8.5. The low pH values might have come from the source of the water or the materials used in the construction of the wells and the soil type (result of natural geological conditions at the site, possibly compounded by acid rain). The soil might have low levels of dissolved CO_3^{2-} and HCO_3^- Acidic water may be soft and corrosive and could contain metal ions. It could leach metals from pipes and fixtures such as copper, lead, and zinc. It could also damage metal pipes and cause aesthetic problems such as metallic or sour taste, laundry staining, or blue-green stains in sinks and drains. Low pH exposure may cause hair fibres to swell in sensitive individuals, gastrointestinal irritation may occur just as high pH results in similar effects. Corrosion of metals and aggression of cement concrete is likely at low pH. The acidity of the well water may, therefore affect constructional works in the locality, and could be the cause of cracks and decay of the cement lining in the wells.

Turbidity was within the WHO permissible level of 5NTU ranging from 1.47± 1.39 to 4.14±7.94. High turbidity values may be due to the presence of clay, silt, finely divided organic matter, plankton and other microscopic organisms. Turbidity can affect the clarity of the water and reduce the depth to which light could penetrate and it has been an indication of poor filtration process of water supplies. The low level of turbidity in this study could be attributed to the fact that human activities including logging, agriculture and road construction contributed to chronic levels of suspended sediment in water may not have affected the wells sampled.

The alkalinity values (ranging from 14.51±5.00 to 15.90± 6.49 mg/L) of all the sampled waters were below the stipulated limit of 100 mg/l by WHO (2011). This again confirmed the slightly acidic nature of water of the water samples. Hence, water from these shallow wells requires some level of treatment to attain the required WHO standard.

Chloride (Cl^-) in groundwater comes from both natural and anthropogenic sources, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas. Higher chloride content generally indicates fecal pollution. Chlorides (Cl^-) level (61.78 ± 10.95 to 67.11 ± 13.84mg/l) in the water samples were higher than those reported by Tesi *et a*l. (2013) but within the WHO maximum acceptable WHO (2011) limit of 200mg/l for drinking water.

Mean values of Nitrates obtained ranges from 5.73 ± 0.93 to 5.86 ± 0.98mg/l. Nitrates (NO_3^-) concentrations were considered to be normal and within the WHO (2011) permissable limit of 50mg/L for drinking water. Nitrate may occur naturally although its presence in water is more often associated with contamination by excessive use of fertilizers in combination within appropriate farming practices and improper disposal of sewage.

For water to be considered no risk to human health, the total coliform bacteria and *E.coli* in water sample should be zero (WHO, 2011). Total coliform bacteria count ranged from 3.48 ± 1.78 to 10.56 ± 4.90 cfu/100ml and that of *E.coli* ranged from 0.33 ± 0.5 to 1.22±1.09cfu/100ml. Total coliform and *E.coli* count, recorded values were not within WHO acceptable limit. The high levels of microbial indicators in the wells might be due to soak away pits and latrines in the vicinity that had extended their influence on water qualities or presumably, the extreme high values of these microbial indicators recorded in the water samples, might be due to anthropogenic activities by human. The microbial indicator levels observed at these sampling sites make water unsuitable for drinking (WHO, 2011), and will pose significant health risks to humans.

CONCLUSION

The study was untaken with the aim to analyze the physico-chemical parameters, heavy metal concentrations and microbial contents of the water samples collected from selected shallow hand-dug wells in Isoko North Local Government Area of Delta State. From the results obtained, it were observed that most physico-chemical parameters were within the permissible guideline of WHO (2011) with the exception of DO, BOD and COD which were higher than the WHO standard for drinking water. This indicated that the well water within the study areas were contaminated and can pose risk to the populace using the water for domestic and drinking purposes. Also it was observed that Sulphate exceeded the permissible limit of 200mg/L set by WHO (2011).

The concentration of Fe, Zn, Pb, Mn and Cd analyzed in the water samples of the wells exceeded the WHO (2011) standard limits except for Cr which was within the standard limits in all the wells studied. High level of heavy metals can pose harm to the rural dwellers that uses these water sources for drinking and other domestic uses.

The values obtained from the microbial analysis indicate high densities of total coliform count and E.coli in the water samples studied. This is an indication of faecal contamination of the water. The contamination may be due to the sewage leakage and other impurities from non-point sources.

RECOMMENDATIONS

The following recommendations were made based on the results obtained from the study:

- It is recommended that standard measures be taken by water users to ensure proper treatment of the water (filtration and boiling) before use to safeguard their health.
- The inhabitants should be educated on the need to keep their surroundings clean most especially around the wells
- Hygienically approved methods for waste disposal (both solid and liquid) should be explored and adopted to check the possibilities of indiscriminate land-dumping of potentially hazardous waste materials. These Governmental policies on waste disposal and management should be enacted and strictly enforced.
- It is also recommended that water quality analysis be carried out on all the wells in the area frequently. This will ensure that incidences of contamination are noticed earlier for remedial action to be taken.

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