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Assessing The Effect of Heavy Metals on Ground Water Portability around Uwelu Spare Parts, Benin City, Edo State

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Abstract

Six (6) borehole water samples around Spare-part market area in Uwelu in Egor Local Government Area of Southern Nigeria were collected to ascertain its potability. The Study assessed the physicochemical and heavy metals parameters using Atomic Absorption Spectrometer. The physical parameters water (borehole) samples analyzed includes, TDS, pH, EC, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity. The heavy metal parameters analyzed in the borehole water samples includes, Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium. The pH ranges 6.85 to 7.1. Electrical Conductivity ranges from 20.7uS/cm to 139.37uS/cm. Total Dissolved Solids range from 9.8mg/l - 68.4mg/l. Chromium concentration range from 1.136mg/l - 3.650mg/l. Lead range from 0.005mg/l - 0.015mg/l. Copper range from 0.028mg/l - 0.163mg/l. The heavy metal parameters analyzed reveal that Cadmium range from 0.001mg/l - 0.007mg/l. Zinc range from 0.244mg/l - 0.332mg/l. Manganese range from 0.016mg/l - 0.043mg/l. Nickel range from 0.010mg/l - 0.034mg/l. Generally, borehole water quality can be said to be potable as a result of all other parameters being below the threshold value besides pH using WHO, FEPA and SON Standards. Also, the result shows a high concentration of hexavalent chromium across the wells and the borehole water quality can be said to be potable as a result of all heavy metal parameters being below the threshold value besides hexavalent chromium using SON, FEPA and WHO Drinking Water Standards. The study suggests water study to be done to ascertain the course of the high concentration of the pH and hexavalent chromium.

Keywords: *Groundwater; World Health Organization (WHO); Federal Environmental Protection Agency (FEPA); Standard Organization of Nigeria (SON); Uwelu Spare-part Market.*

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1. INTRODUCTION

Technological improvement has made water demand for several utilization to transcend from mere finds of surface water to better and quality groundwater exploration which has serve as means of survival for the masses (Dickenson and Kekwaru, 2021).

Water is one of the most widely used natural resource and gotten mostly from groundwater. It supports human health, socio-economic activities as well as ecosystem functionality (Humphreys, 2009; Staube *et al.,* 2009). Water (rivers, streams and ponds), atmosphere water available to people in general (Adetude *et al.,* 2011). The quantities of these sources of water are in wide variationas a result of environmental influence according to Tay (2007). The main origin of borehole water is rainfall which enters into the ground and drains through soil and pore space of rock. Water makes the major ingredients for development activities. Groundwater quality is one of the main relevant aspects in the study of hydrogeology. Recently, fresh water demand has increased tremendously due to population growth and intensive agricultural activities. It has become imperative to monitor drinking water quality because many water resources majorly in growing nations are unhealthy for consumption because bear detrimental agents. Studies have revealed varying degrees of contamination from both natural and anthropogenic sources, including heavy metals and microbial organisms. Boreholes are the most common source of groundwater in Benin – City, Nigeria followed by wells, springs and infiltration galleries. The depth to aquifer varies significantly ranging from approximately 25.5 meters to 148.7 meters and the water table depths ranges from 5.73meters to 12.57 metres Benin – City, Nigeria. In Egor Local Government Are, groundwater quality has shown signs of deterioration, potentially due to both natural and human – induced contamination. The present work is to assess the portability of groundwater at Spare-part market area in Uwelu, southern, Nigeria.

Study Area

The area of study is within latitude 5°22′20″N - 5°22′40″N, and longitude 5°35′30″E - 5°36′0″E. The area of study is situated in western Niger Delta (Fig. 1).

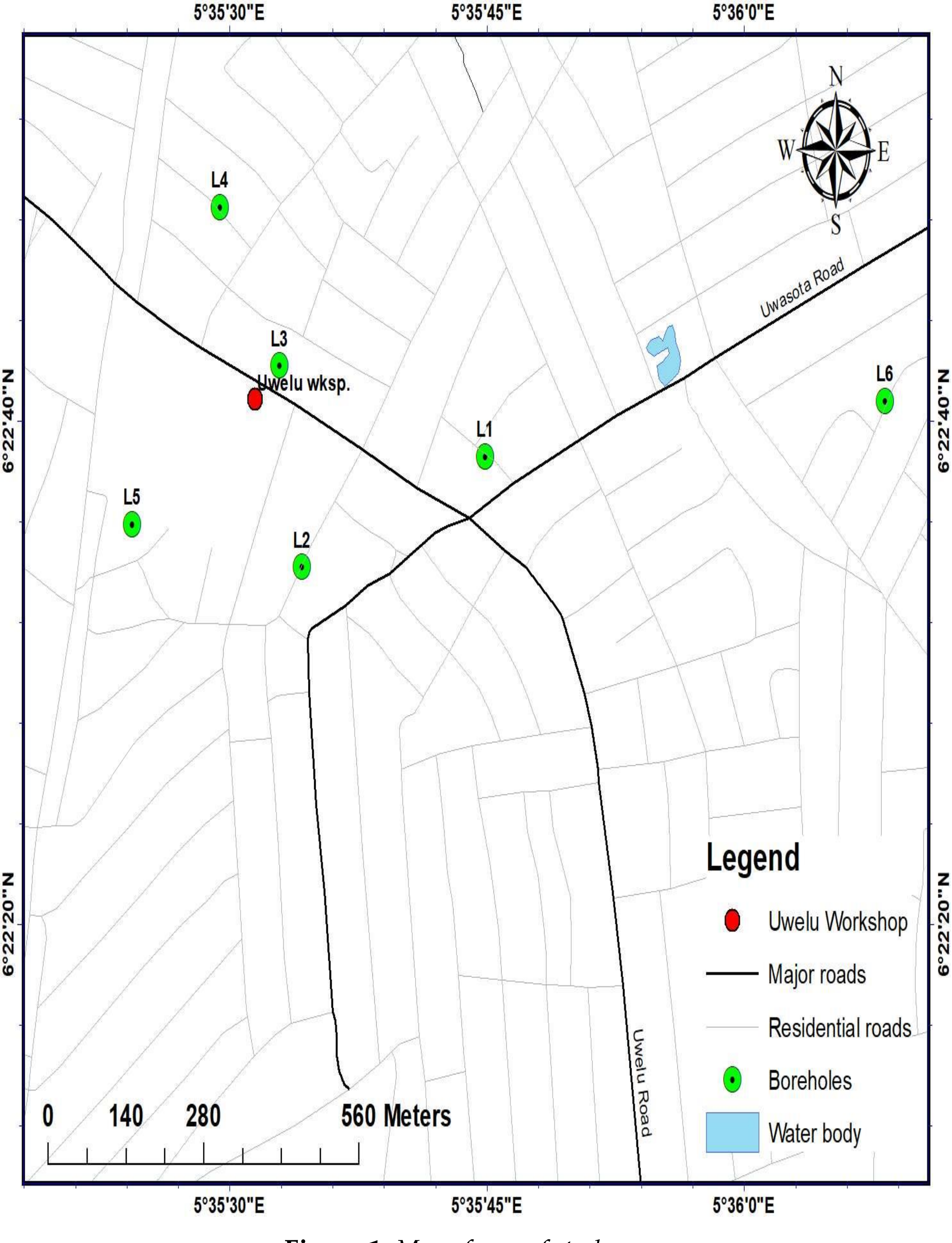


Figure 1: *Map of area of study*

Geologic Setting

Cenezoic Niger Delta is a prolific petroleum basin with an area space of 105000 km² (Avbovbor, 1978) regarded as one of world largest Delta complexes with major hydrocarbon provinces (Doust and Omatsola, 1990). The Niger-Delta sedimentary basin lies within longitudes 4^0Eand 8.8^0E and latitudes 3^0N and 6^0N and is one of the most prolific global hydrocarbon system. It was developed along a failed arm of a triple junction system (aulacogen) which initially started at the division of South American and African plates in the late Jurassic (Burke, 1972). The two arms that followed the southwestern and southeastern coast of Nigeria and Cameroon progressed into the passive continental margin of West Africa, the third failed arm result into the Benue Trough. The remaining depocenters along the African Atlantic coast likewise add to deltaic creation. Syn-rift sediments gathered at Cretaceous to Tertiary time, with the earliest sediments of Albian age. Thickest successions of syn-rift marine and marginal marine clastics and carbonates were laid in a series of transgressive and regressive phases (Doust and Omatsola, 1989). The Syn-rift phase climax with inversion of the basin at Santonian (Late Cretaceous). Renewed subsidence results when the continents break and the sea transgressed the Benue Trough. The Niger-Delta clastic wedge further advance during Middle Cretaceous time into a depocenter situated above the collapsed continental margin at the location of the triple junction. Supply of sediment was majorly along drainage systems that followed two failed rift arms, the Benue and Bida Basins. At the Late Cretaceous, sediment progradation was affected by episodic transgressions.

At Tertiary, supply of sediment was mainly from the north and east through the Niger, Benue and Cross Rivers. Cross and Benue Rivers yielded adequate quantity of volcanic detritus from the Cameroon volcanic zone starting from Miocene time. The Niger-Delta clastic wedge prograded into the Gulf of Guinea at a progressively increasing rate, with regards to the evolution of these drainage areas and continued basement subsidence. Regression rates increased in the Eocene, with an increasing volume of sediments accumulated since the Oligocene.

Normal faults triggered by the movement of deep-seated, overpressured, ductile, marine shale have changed several of Niger-Delta clastic wedge (Doust and Omatsola, 1989). Many of these faults were created at delta progradation period and were syndepositional, affecting sediment dispersal. Slope instability followed fault growth along the continental margin. Faults flatten with depth onto a master detachment plane near the top of the overpressured marine shale at the base of the Niger-Delta succession. The complex nature of structures in local areas reflects the density and style of faulting. Simple structures, like flank and crestal folds, develops along individual faults. The listric fault trend and differential loading of deltaic sediments beyond ductile shale causes hanging-wall rollover anticlines. More complex structures, cut by swarms of faults with varying amounts of thrown, include collapsed-crest feature with domal shape and potent repulsive fault follows vertically at depth.

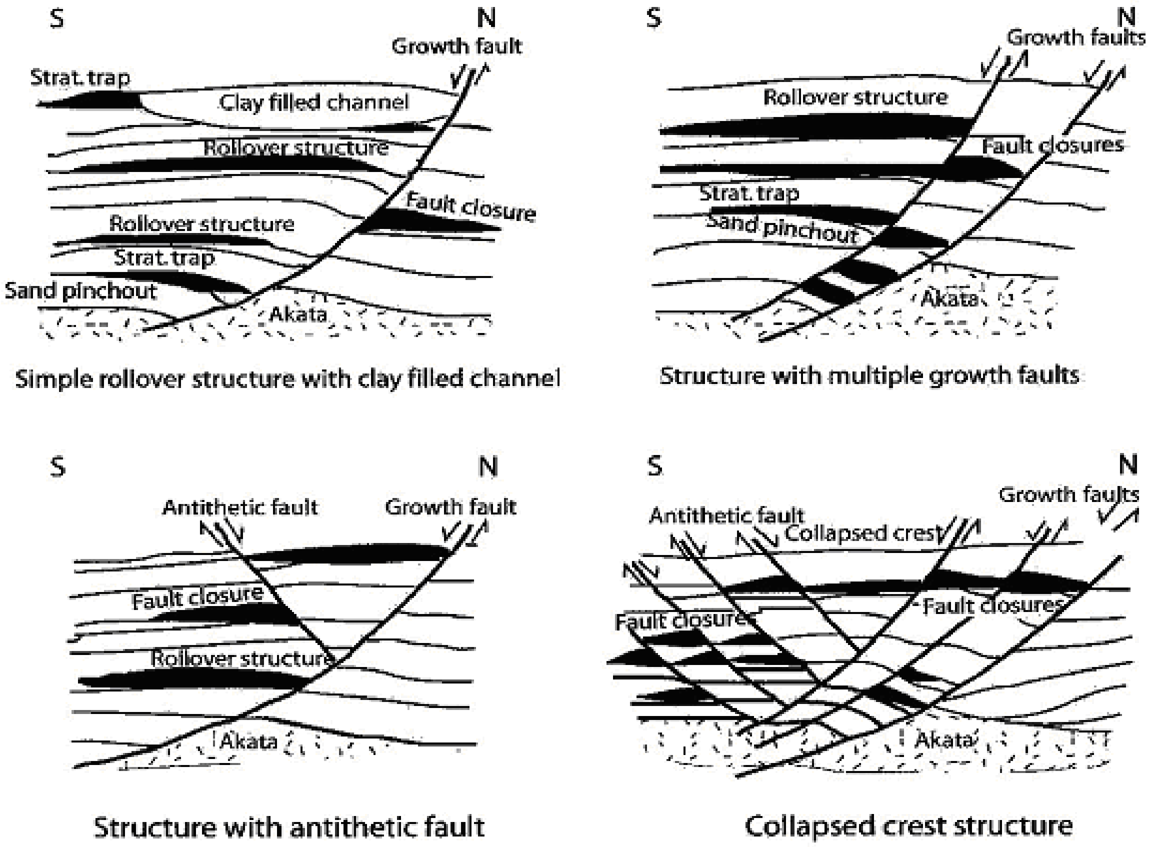


Figure 2: *Oil field structures and associated traps of the Niger Delta [Extracted from Doust and Omatsola (1990); Stacher (1995)].*

Onshore Niger Delta province is typified by southern Nigeria geology with southwest Cameroon. The north boundary is the Benin flank on east north eastern trending hinge line south of the West Africa basement massif. The north eastern boundary is define by outcrops of the Cretaceous on the Abakiliki High and further east – south east by Calabar flank in a hinge line ending adjacent Precambrian. The Niger-Delta Tertiary portion is separated into three portion reflecting advancing depositional facies which are recognized mainly by sand – shale ratio.

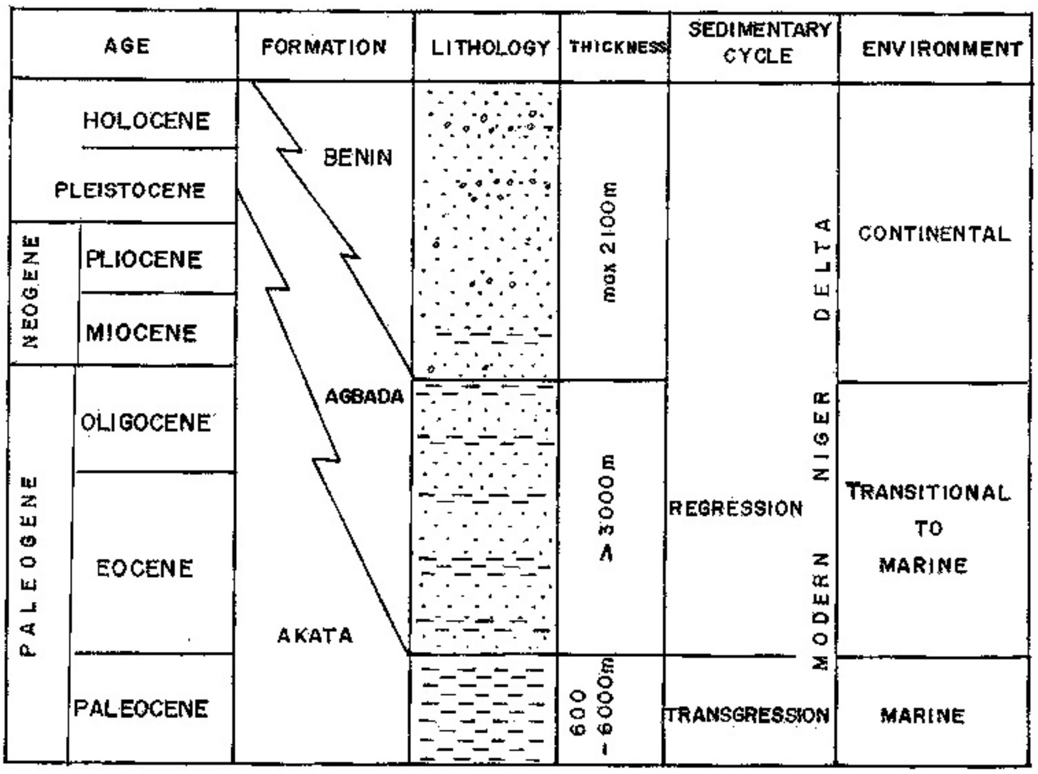
Local Geology

The area under study is overlain with over 20 feet thick lateritic overburden at the surface. Below the lateritic overburden is fine to coarse grain sandstone which is underlain by clay sand to clay. The depth to water table is over 200feet with elevation of over 100m above sea level. The area is drain by the Ikpoba River the main river in Benin City.

Niger Delta Stratigraphy

The three major lithostratigraphic units defined in the subsurface of the Niger-Delta (Akata, Agbada and Benin Formations).

Table 1: *Stratigraphy of Niger Delta (adapted after Ajibola, 2004)*



2. MATERIALS AND METHOD

Samples were collected around Uwelu Spare-part Market Uwelu-Uwasota, Benin City, Egor Local Government Area, Edo state, Nigeria, these analyzed for groundwater quality. This involves the physicochemical parameters and heavy mineral concentration. Other materials used for this study includes; Seven (7) 2-litre transparent plastic cans, three (3) 50cl polythene bags, concentrated nitric acid and 5ml syringe, GPS, analogue Mercury-in-Glass thermometer (Graduated in degree centigrade), Measuring tape, thermometer, pH meter, electrical conductivity meter biro, pencil, computer system, wristwatch and pH / EC / TDS high range meter (Model Hanna HI991301). Random collection for borehole water samples was carried out in Uwelu-Uwasota community within the study area. Six (6) water (borehole) samples were collected from the study area.

Borehole water collection was done by taking water samples in new 2-litre opaque polythene plastic cans. The cans were washed well with water from the boreholes (Cased or uncased) being sampled. Two drops of concentrated nitric acid was added to each of the samples in order to homogenize the sample and prevent absorption or adsorption of the heavy metals to the walls of the container. The temperature, pH and electrical conductivity of the water sample were done in-situ with thermometer, pH meter and EC meter.

Borehole water samples collected from the field were kept in 120ml rubber bottle and then placed in a mini cooler with ice cheeps to keep the temperature under control and immediately taken to the laboratory for the determination of various parameters. The water temperature samples was taken inplace at the location while other parameters were carefully determined in laboratory according to the acceptable standard (Adelekan and Abegunde, 2011; Allen *et al*; 1974).

3. RESULT AND DISCUSSION

Table 2: *Physicochemical and Heavy Metal Parameters.*

Parameters	UNITS	L1	L2	L3	L4	L5	L6
Ph	-	7.1	6.95	6.91	6.94	6.96	6.85
EC	µS/cm	85.1	20.7	22.2	82.4	51.7	139.3
TDS	mg/l	42.6	9.8	10.5	39.7	22.8	68.4
Turbidity	NTU	1	0	0	1	0	1
TSS	mg/l	0	0	0	0	0	0
TS	mg/l	42.6	9.8	10.5	39.7	22.8	68.4
Salinity	mg/l	26.4	5.2	6.7	19.4	12.6	34.8
Hardness	mg/l	8	6	6	7	7	9
Alkalinity	mg/l	12	8	9	10	10	14
Nitrate	mg/l	2.45	2.77	2.23	2.85	2.50	3.10
Phosphate	mg/l	0.28	0.34	0.25	0.39	0.34	0.39
Sulphate	mg/l	5	3	4	6	4	7
Cu^{2+}	mg/l	0.054	0.028	0.127	0.163	0.124	0.152
Pb^{2+}	mg/l	0.011	0.009	0.005	0.008	0.013	0.015
Cr^{6+}	mg/l	1.343	2.004	1.136	2.978	3.650	2.726
Ni	mg/l	0.012	0.010	0.023	0.034	0.030	0.034
Mn^{2+}	mg/l	0.019	0.024	0.016	0.043	0.061	0.027
Zn^{2+}	mg/l	0.287	0.294	0.318	0.244	0.284	0.332
Cd^{2+}	mg/l	0.007	0.001	0.001	0.001	BDL	BDL
Fe^{3+}	mg/l	0.547	0.399	0.097	0.182	0.354	0.528

Concentration in mg/l, BDL: Below detection limit

The physicochemical parameters analyzed for in location 1 to 6 pH, EC, TDS, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity while others include cation includes, anion and COD. The result shows pH range of 6.85 mg/l to 7.1 mg/l, EC range of 20.7 μS/cm to 139.3 μS/cm, TDS range of 9.8mg/l to 68.4 mg/l, Turbidity range of, 0NTU to 1NTU, TSS of 0mg/l, TS range of 9.8 mg/l to 68.4 mg/l, Salinity range of 5.2mg/l to 34.8mg/l, Hardness range of 6mg/l to 9mg/l, Alkalinity range of 8mg/l to 14mg/l, Nitrate range of 2.45 mg/l to 3.10mg/l, Phosphate range of 0.25mg/l to 0.39mg/l and Sulphate range of 3mg/l to 7mg/l.

The heavy metals parameters analyzed in location 1 to 6 includes Cu^{2+} , Pb^{2+} , Cr^{6+}, Ni , Mn^{2+} , Zn^{2+} , Cd^{2+} and Fe^{3+}. The results shows Cu^{2+} range of 0.028 mg/l to 0.163mg/l, Pb^{2+} range of 0.005 mg/l to 0.015mg/l, Cr^{6+} range of 1.136 mg/l to 3.650mg/l, Mn^{2+} range of 0.016mg/l to 0.061mg/l, Zn^{2+} range of 0.244 mg/l to 0.332mg/l, Cd^{2+} range of BDL to 0.007mg/l and Fe^{3+} range of 0.182 mg/l to 0.547mg/l.

Table 3: *Physicochemical and Heavy Metal Parameters as compared with (SON, 2005; FEPA, 1991; and WHO, 2006)*

Parameters	UNITS	L1	L2	L3	L4	L5	L6	SON	FEPA	WHO
Ph	-	7.1	6.95	6.91	6.94	6.96	6.85	6.5	6.0	7.0
EC	μS/cm	85.1	20.7	22.2	82.4	51.7	139.3	1000	N/A	1000
TDS	mg/l	42.6	9.8	10.5	39.7	22.8	68.4	500	N/A	500
Turbidity	NTU	1	0	0	1	0	1			
TSS	mg/l	0	0	0	0	0	0			
TS	mg/l	42.6	9.8	10.5	39.7	22.8	68.4			
Salinity	mg/l	26.4	5.2	6.7	19.4	12.6	34.8	N/A	N/A	N/A
Hardness	mg/l	8	6	6	7	7	9			
Alkalinity	mg/l	12	8	9	10	10	14	100	N/A	100
Nitrate	mg/l	2.45	2.77	2.23	2.85	2.50	3.10			
Phosphate	mg/l	0.28	0.34	0.25	0.39	0.34	0.39	N/A	N/A	N/A
Sulphate	mg/l	5	3	4	6	4	7	500	N/A	500
Cu^{2+}	mg/l	0.054	0.028	0.127	0.163	0.124	0.152	-	-	-

Pb^{2+}	mg/l	0.011	0.009	0.005	0.008	0.013	0.015	0.01	0.05	0.01
Cr^{6+}	mg/l	1.343	2.004	1.136	2.978	3.650	2.726	0.05	N/A	0.05
Ni	mg/l	0.012	0.010	0.023	0.034	0.030	0.034	N/A	N/A	N/A
Mn^{2+}	mg/l	0.019	0.024	0.016	0.043	0.061	0.027			
Zn^{2+}	mg/l	0.287	0.294	0.318	0.244	0.284	0.332	3.0	5.0	5.0
Cd^{2+}	mg/l	0.007	0.001	0.001	0.001	BDL	BDL	0.003	N/A	0.003
Fe^{3+}	mg/l	0.547	0.399	0.097	0.182	0.354	0.528	0.3	0.3	0.3

Concentration in mg/l, BDL: Below detection limit

The overall results shows that pH value of 7.1 for location 1 was above the allowable level needed in water consumption when compared with the standards of SON (2006), FEPA (1991) and WHO (2006). The EC and the TDS for location 1 were far below the permissible limit required in water consumption when compared with the standards of SON (2006) and WHO (2006). The overall result from the borehole in location 1 affirm that the water obtained from this borehole is fit for drinking. The physicochemical parameters analyzed for in location 2 includes; pH, EC, TDS, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity while others include cation, anion and COD. The results shows that pH value of 6.95 for location 2 was above the permissible limit required in water consumption when compared with the standards of SON (2006) and FEPA (1991). The EC and TDS for location 2 were far below the permissible limit required in drinking water when compared with the standards of SON (2006) and WHO (2006). The overall result from the borehole in location 2 affirm that the water obtained from this borehole is fit for drinking. The physicochemical parameters analyzed for in location 3 include; pH, EC, TDS, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity while others include cation, anion and COD. The results shows that pH value of 6.91 for location 3 was above the permissible limit required in water consumption when compared with the standards of SON (2006) and FEPA (1991). The EC and the TDS for location 3 were far below the permissible limit required in drinking water when compared with the standards of SON (2006) and WHO (2006). The overall result from the borehole in location three 3 affirm that the water obtained from this borehole is fit for drinking. The anion and cation also reveals a value below the permissible limit set by authorized agencies and organization for drinking water (Table 3). The physicochemical parameters analyzed for in location 4 include; pH, EC, TDS, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity while others include cation, anion and COD. The results shows that pH value of 6.94 for location 4 was above the permissible limit required in water consumption when compared with the standards of SON (2006) and FEPA (1991). EC with TDS for location 4 were far below the permissible limit required in water consumption when compared with standards of SON (2006) and WHO (2006). The overall result from the borehole in location 4 affirm that the water obtained from this borehole is fit for drinking. The anion and cation also reveals a value below the permissible limit set by authorized agencies and organization for drinking water (Table 3). The physicochemical parameters analyzed for in location 5 include; pH, EC, TDS, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity) while others include cation, anion and COD. The results shows that pH value of 6.96 for location 5 was above the permissible limit required in water consumption when compared with the standards of SON (2006) and FEPA (1991). EC with TDS for location 5 were far below the permissible limit required in drinking water when compared with the standards of SON (2006) and WHO (2006). The overall result from the borehole in location five (5) affirm that the water obtained from this borehole is fit for drinking. The anion and cation also reveals a value below the permissible limit set by authorized agencies and organization for drinking water (Table 3). The physicochemical parameters analyzed for in location 6 include; pH, EC and TDS) while others include cation, anion and COD. The results shows that pH value of 6.85 for location 6 was above the permissible limit required in water consumption when compared with the standards of SON (2006) and FEPA (1991). The EC and the TDS for location 6 were far below the permissible limit required in drinking water when compared with the standards of SON (2006) and WHO (2006). The overall result from the borehole in location 6 affirm that the water obtained from this borehole is fit for drinking.

The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium in location one (1). The analyzed heavy metals shows an acceptable result with the permissible limit required in drinking water when compared with the standards of SON (2006), FEPA (1991) and WHO (2006) except hexavalent chromium, cadmium ion and iron (III) which were above the required threshold value for location one (1). The overall result from the borehole in location one (1) affirm that the water obtained from this borehole is fit for drinking, however, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium and iron (III) in the well.

The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium in location two (2). The analyzed heavy metals shows an acceptable result with the permissible limit required in drinking water when compared with the standards of SON (2006), FEPA (1991) and WHO (2006) except hexavalent chromium, cadmium ion and iron (III) which were above the required threshold value for location two (2). The overall result from the borehole in location two (2) affirm that the water obtained from this borehole is fit for drinking, however, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium and iron (III) in the well.

The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium in location three (3). The analyzed heavy metals shows an acceptable result with the permissible limit required in drinking water when compared with the standards of SON (2006), FEPA (1991) and WHO (2006) except hexavalent chromium which was above the required threshold value for location three (3). The overall result from the borehole in location three (3) affirm that the water obtained from this borehole is fit for drinking, however, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium in the well.

The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium in location four (4). The analyzed heavy metals shows an acceptable result with the permissible limit required in drinking water when compared with the standards of SON (2006), FEPA (1991) and WHO (2006) except hexavalent chromium which was above the required threshold value for location four (4). The overall result from the borehole in location four (4) affirm that the water obtained from this borehole is fit for drinking, however, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium in the well.

The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium in location five (5). The analyzed heavy metals show an acceptable result with the permissible limit required in drinking water when compared with the standards of SON (2006), FEPA (1991) and WHO (2006) except hexavalent chromium and iron (III) which were above the required threshold value for location five (5). The overall result from the borehole in location five (5) affirm that the water obtained from this borehole is fit for drinking, however, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium and iron (III) in the well.

The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium in location six (6). The analyzed heavy metals shows an acceptable result with the permissible limit required in drinking water when compared with the standards of SON (2006), FEPA (1991) and WHO (2006) except hexavalent chromium and iron (III) which were above the required threshold value for location six (6). The overall result from the borehole in location six (6) affirm that the water obtained from this borehole is fit for drinking, however, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium and iron (III) in the well.

4. CONCLUSION

Ground water portability around Uwelu Spare Parts, Benin City, Edo State was studied to assess the effect of Heavy Metals. The physicochemical parameters analyzed for in all the locations include; pH, EC, TDS, TSS, TS, Hardness, Turbidity, Salinity and Alkalinity while others include cation, anion and COD. The heavy metal parameters analyzed for includes Lead, Manganese, Nickel, Chromium, Copper, Zinc, Iron and Cadmium. The results were compared with the standards of SON (2006), FEPA (1991) and WHO (2006). The obtained result reveals that the ground water assessed in the studied area are not contaminated with heavy metals, cations and anions. The hexavalent chromium, cadmium ion, iron (III) and pH values were moderately okay despite they were fairly above the permissible limit set by SON (2006) and FEPA (1991) for drinking water. Generally, the borehole water assessed in the studied area can be regarded as clean water, thereby fit for consumption. However, further investigation have to be carried out to determine the cause of the high level of hexavalent chromium and iron (III) in the well.

CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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