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The Impact Of Lignite Depost On The Spring Water Quality In Parts Of Orlu, Imo State, Southeastern Nigeria.

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Abstract

The impacts of lignite deposits on some spring water resources in Orlu area of Imo State, southeastern Nigeria are discussed. A total of four springs were investigated.Lignite seams associated with pyrite, outcrop at three of the springs (Ihioma, Umuhu Okabia and Ubaha) while the fourth (Mgbede) lies in an area that is not underlain by lignite. The results indicate that the mean concentrations of the pH, electrical conductivity and total dissolved solids (TDS) of the Ihioma spring water were 4.5, 60.5µS/cm and 35.4 mg/l respectively while the mean values for Umuhu Okabia were 5.6, 52.3µS/cm and 42 mg/l respectively. The mean pH, electrical conductivity and TDS concentrations for Ubaha spring were 5.5, 73µS/cm and 50.3mg/l respectively.They total iron for Ihioma, Umuhu Okabia, Ubaha and Mgbede were 15, 16.5, 20.2 and 0.03mg/l respectively while the total organic carbon (TOC) for Ihioma, Umuhu Okabia and Ubaha were 4.7, 4.4 and 4.8mg/l respectively. The concentrations of major cations and anions of all the springs were in conformity with World Health Organization (WHO) 2006 drinking water standard. However, the pH and total iron concentrations of the springs (Ihioma, Umuhu Okabia and Ubaha) were not in conformity with WHO (2006) standard and thus constitute a threat to their water quality. The high levels of total iron and low pH values indicates the impact of the lignite seams on the spring water quality.

Key words: Lignite seams, spring water- Orlu, pH, total organic carbon (TOC), and pyrite

1.0 Introduction

Nigeria is blessed with abundant surface and ground-water resources. The water resources plan for Nigeria prepared by Japan International Co-operation Agency (JICA) indicate an estimated surface water resources of 2.67 x 1011m^3/year and underground storage of 0.52x1011 m^3/year (Oteze, 2006) These figures greatly outweigh the country's total water demand of 0.40x1011 m^3/year. However, a major tide militating against their sustainable development is pollution. The surface water resources are generally more vulnerable to pollution than groundwater resources (Ogunbanjo and Rolajo, 2004). Some groundwater resources are highly vulnerable to pollution due to geologic setting and or human activities. This implies the need for constant assessment of both groundwater and surface water quality. The groundwater resources in Orlu area of Imo State, Nigeria include Ihioma, Ubaha , Umuhu Okabia and Mgbede springs (Figure 1).

Although some studies (Ahiarakwem ,2004, Ahueke,1999 and Nwankwor,1993) have been carried out on some spring water resources in Southeastern Nigeria, there is paucity of information on the impact of lignite seams in this region on the spring water quality.

The spring water resources in Orlu area are of strategic importance to both the Imo State Government of Nigeria and the local community. To the former, it constitutes a focal point for sustainable tourism development while to the latter, it is the main domestic water supply source. The lignite seams in the studied area have the potential to alter the chemical characteristics of the springs, thus changing their resource status and usefulness. There is therefore need for constant assessment of the bio-chemical characteristics of the springs as well as, development of appropriate pollution preventive mitigation strategy for the resources.

2.0 Climatic Conditions

The spring water resources in Orlu are located within the equatorial climate belt of Nigeria. The mean monthly temperature of the area ranges from 25 to

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28.50C while the mean rainfall is about 2,500mm, most of which falls between the months of May and October. However, the mean monthly precipitation range from 9 to 302mm (National Root Crop Research Institute, 2010). .

The vegetation cover of the study area is characterized by trees and shrubs of the rainforest belt of Nigeria. However, human activities such as farming and construction of civil structures in the area have resulted in the removal of part of the vegetation .

3.0 Geology and Hydrology

The studied area is located within two formations; Ogwashi-Asaba and Ameki (Figure 1). The Ogwashi-Asaba Formation (upper Eocene) consists of lignite seams, sandstone and clay units while the Ameki Formation (lower Eocene) consists of mudstones, sandstone, shales and clays. The Ogwashi-Asaba Formation is overlain by Benin Formation; a major lithostratigraphic unit in the Niger Delta basin of Nigeria and underlain by the Ameki Formation. The Benin Formation (Pliocene to Miocene in age) consists of friable coarse sands with intercalations of shale-clay lenses, some isolated units of gravels, conglomerates and sandstones (Ananaba *et al*., 1993). The Ihioma, Umuhu Okabia and Ubaha springs are located within the Ogwashi-Asaba Formation while the Mgbede spring is located within the Ameki Formation. The general stratigraphic sequence (from top to bottom) at the springs located within the Ogwashi- Asaba Formation are: Laterite, mudstone, clay, sandstone and lignite. The estimated average thickness of the laterite, mudstone, clay, sandstone and lignite seams are 25, 0.40, 0.52, 1.6 and 1.0 m respectively. The stratigraphic sequence (from top to bottom) at Mgbede spring are: laterite, sandy clay, sandstone and clay. The estimated thickness of these units are, 25, 3.0, 3.5 and 0.6 m respectively. The springs issue out from the sandstone unit in both Formations.

The measured specific discharge (based on Reynold number) of Ihioma, Umuhu Okabia, Ubaha and Mgbede springs are 2,400, 2,600, 2,500 and 2,700 litres/hour respectively. The four springs flow all the year round and are adequately recharged by precipitation..

4.0 Materials and Methods

Water samples were obtained at Ihioma, Umuhu Okabia, Ubaha and Mgbede springs (See Figure 1). Sampling was carried out for a period of one year (2010) on a bi-monthly basis commencing from January and ending in November. Three sterilized 2.5 liters bottles were used to collect the water samples using the grab method. The bottles were corked soon after they were obtained so as to prevent oxidation. One of the sample bottles was analyzed immediately for physical parameters (pH, electrical conductivity and total dissolved solids (TDS)) using digital meters; the second bottle was preserved in an ice water (below 5^0C) and later sent to the laboratory for analysis of major cations and anions using Atomic Absorption Spectrometer (AAS). The third bottle meant for microbial analysis and total organic content (TOC) determination was treated in quick succession in 1ml potassium fluoride solution and 2ml manganese sulphate and properly mixed and corked. This third bottle was later sent to the laboratory within 24 hours of collection for analysis. The microbial analysis and TOC determination were conducted using standard plate and ASTM D3579 methods respectively.

The concentrations of the major cations and anions of the springs were converted from milligram/liter to milliequivalent/liter using equation 1 and used to construct Stiff and Piper trilinear diagrams. (See Figures 2 and 3).

Milliequivalent(liter-1) =Milligram (liter-1)/ Equivalent mass ....…………………(1)

The mean concentrations of Na^+, Ca^{2+} and Mg^{2+} in milliequivalent/litre were used to determine the sodium adsorption ratio (SAR) values. The SAR was determined using the method (equation 2) developed by United State Department of Agriculture (1965).

$SAR=Na^+/(Ca^{2+}+Mg^{2+}/2)^{0.5}$ ………………...(2)

The thickness of the stratigraphic units at the springs were estimated while the specific discharge of the springs were determined using V- Notch method.

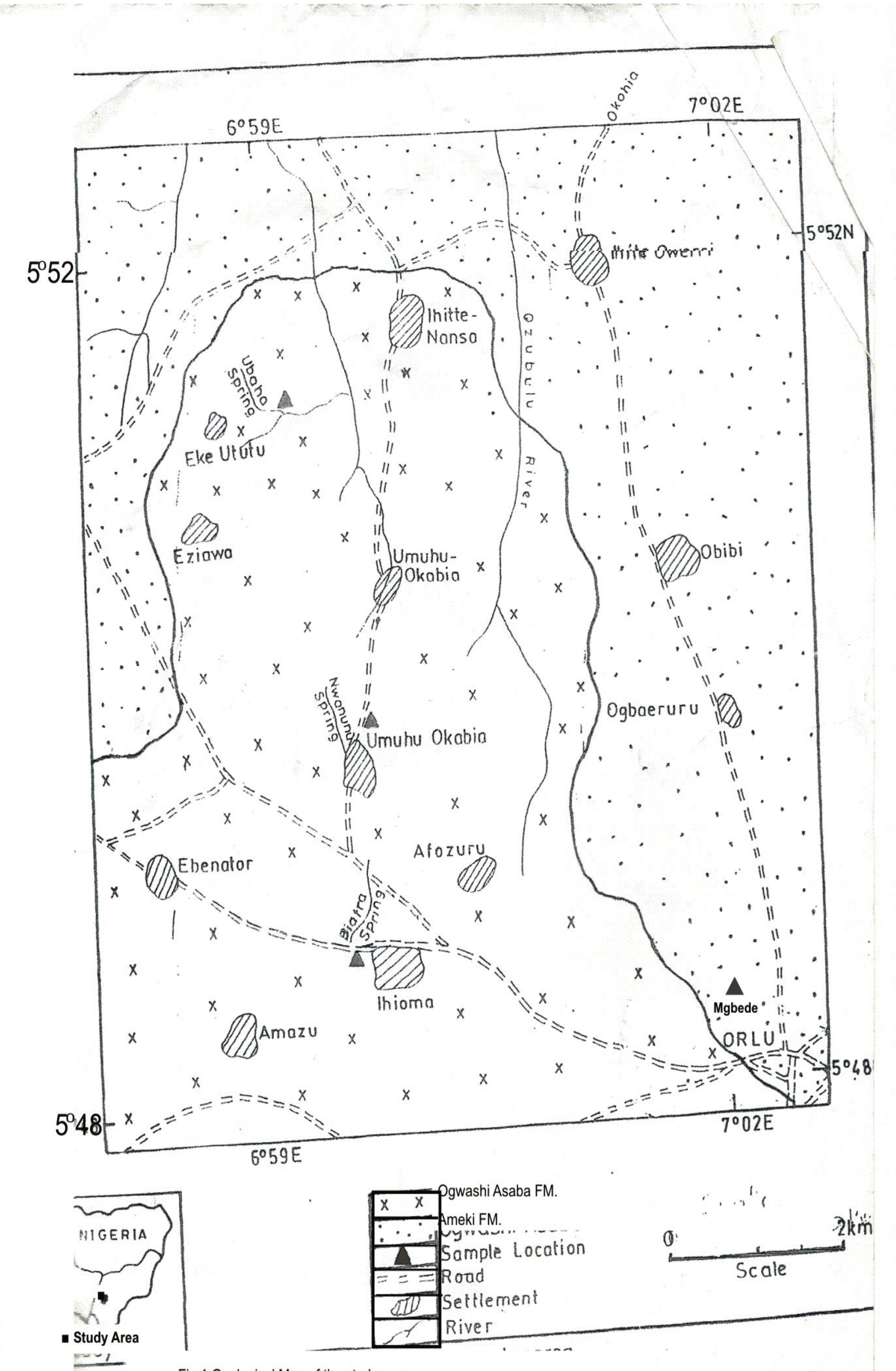

Fig 1 Geological Map of the study area

5.0 Results and Discussion

The results of the field measurements (pH, total dissolved solids and electrical conductivity) as well as laboratory analysis of the springs are shown in Table 1. The conversion of the major cations and anions of the rivers from mlligram/liter to millequivalent/liter is shown in Table 2.

5.1 Physical Parameters

The mean concentrations of pH, electrical conductivity, total dissolved solids (TDS) of the Ihioma spring are 4.50, 60.5μS/cm and 35.4mg/l respectively while the values for Umuhu Okabia are 5.60, 52.3μS/cm and 42mg/l respectively. The mean values of these parameters for Ubaha are 5.50, 73μS/cm and 50.30mg/l respectively while the mean values for Mgbede spring are 6.70, 40μS/cm and 24mg/l respectively. Except for the pH, the electrical conductivity and total dissolved solids of the springs (Ihioma, Umuhu Okabia and Ubaha) which are located within Ogwashi-Asaba Formation (consisting of lignite seams associated with pyrite) conformed with World Health Organization (WHO) 2006 (Table 1). However, all the measured physical parameters in Mgbede spring (located in Ameki Formation which has no lignite seams and associated pyrite) conformed with WHO (2006) drinking water standard. The acidic nature of the springs located in Ogwashi-Asaba Formation is attributed to the pyrite that is associated with the lignite seams.

Apart from the formation of sulphuric acid, sulphurous acid (H_2SO_3) is also formed following the oxidation of the sulpur in the pyrite to sulphur dioxide (SO_2) and subsequent reaction of SO_2 with water. The formation of sulphuric and sulphurous acids are responsible for the low pH values of the Ihioma, Umuhu Okabia and Ubaha springs. The acidic nature of the springs in the Ogwashi-Asaba Formation is inimical to both humans and animals and thus requires treatment with sodium bicarbonate (Soda ash) so as to raise the pH.

5.2 Total Organic Carbon (TOC) and Iron

The mean concentrations of total organic carbon (TOC) of the Ihioma,, Umuhu Okabia and Ubaha springs are 4.70 and 4.40, 4.80mg/l respectively;

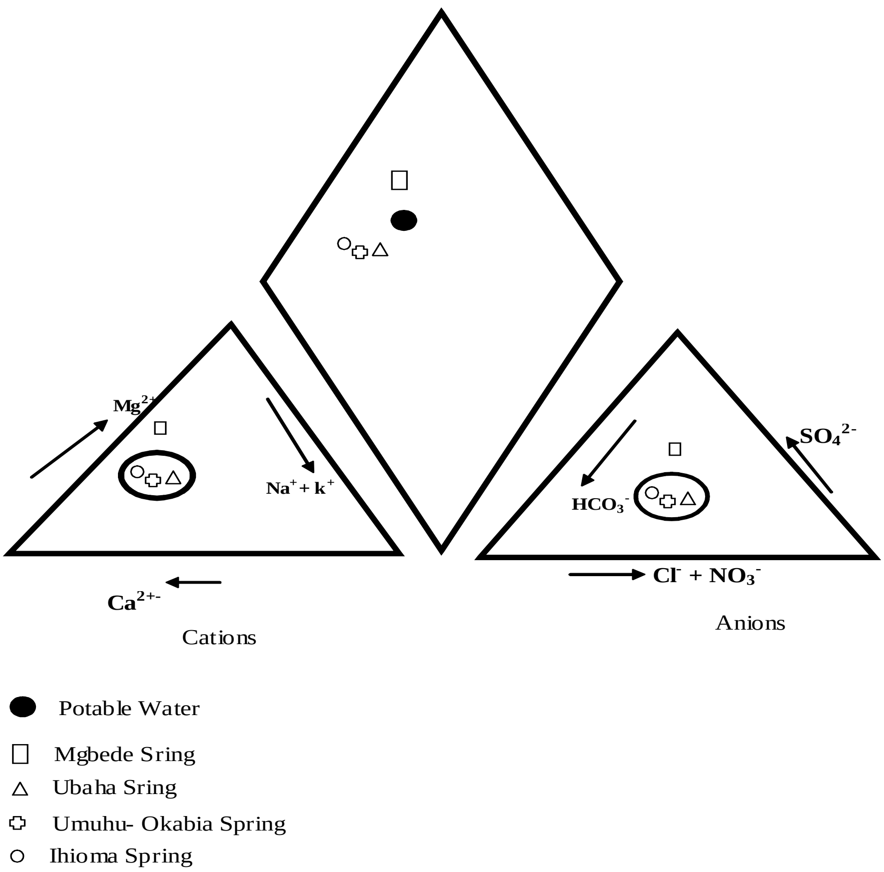

Figure 2: Piper Trilinear of the Ubaha, Umuhu Okabia , Ihioma and Mgbede Springs

no TOC was detected at Mgbede spring. The significant values of TOC in Ihioma, Umuhu Okabia and Ubaha springs are due to the lignite seams associated with the springs. The mean concentrations of total iron of Ihioma, Umuhu Okabia, Ubaha and Mgbede are 15, 16.5, 20.20 and 0.03mg/l respectively. The reaction of the pyrite with water is responsible for the high iron levels in Ihioma, Umuhu Okabia and Ubaha springs. The concentrations of iron in these springs do not conform with WHO (2006) standard. Although iron is essential in the building of the hemoglobin of the human body, excessive concentrations as is the case with Ihioma, Umuhu Okabia and Ubaha springs can stain laundry materials. However, the iron can be treated using aeration method. Hydro-geochemical analysis of surface and subsurface water resources in coal mining areas of Enugu State of Nigeria has been reported to be characterized by low pH and excessive concentrations of iron (Egboka *et. al.*,1988). The current findings conform with their findings. The geologic setting thus plays a vital role in the modification of the chemistry of the springs in the studied area.

5.3 Major Cations and Anions

The mean concentrations of the major cations and anions of the springs (Table 1) conforms with WHO (2006) drinking water standard. The water characteristics of the springs in the Ogwashi-Asaba Formation follow the trend $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ for the cations and $HCO^{-3} > SO_4^{2-} > Cl^- > NO^-{}_3$ for the anions. The major cations trend of the Mgbede spring which is located in the Ameki Formation is $Ca^{2+} > Na^+ > K^+ > Mg^{2+}$ while the trend for the anions is $HCO^{-3} > SO_4^{2-} > Cl^- > NO^-{}_3$. Except for Zn^{2+} and Mn^+ which occur in insignificant quantities, other heavy metals (Cu^{2+} and Pb^{2+}) were not detected in all the springs during the sampling period. The Piper trilinear plot (Figure 2) and Stiff diagram (Figure 3) confirms the impact of geologic setting on the chemistry of the springs. Although all the values are plotted within the potable zone of the Piper diagram, the Stiff diagram clearly shows that the shape and size of the concentrations of the major cations and anions of the springs located in the Ogwashi-Asaba Formation are different from that of Ameki Formation. The mean SAR values for the Ihioma, Umuhu Okabia, Ubaha and Mgbede springs are 1.12, 1.05, 0.85 and 0.36 respectively

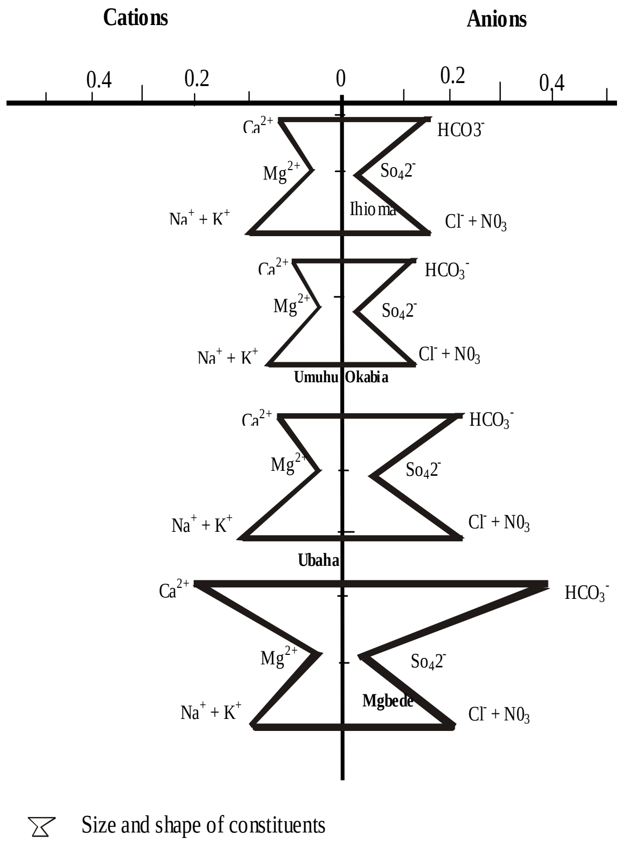

Figure 3: Stiff diagram of the Ubaha, Umuhu-Okabia, Ihioma and Mgbede Springs.

(Table 3). It is interesting to note that the SAR values for Ihioma, Umuhu Okabia and Ubaha are quite close and this may be due to the fact that these springs share similar geologic setting. The Mgbede spring which is located within another Formation (Ameki) has the lowest mean SAR value hence the best for irrigation purposes. According to United States Department of Agriculture (1965) water resources with SAR value of 0 to 10 are considered excellent for irrigation purposes while those with SAR less than 26 are considered poor. However, the low pH values of the springs in the Ogwashi-Asaba Formation implies the need for treatment of the spring water before being used for irrigation purposes.

5.4 Microbial Assay

The mean total coli form count of the Ihioma, Umuhu Okabia, Ubaha and Mgbede springs are 2.0, 4.0, 6.0 and 6,50 cfu/100ml respectively. Although these values are within the WHO (2006) limit, it is necessary to treat the springs with chlorine so as to get rid of the bacteria. It is a fact that poor microbial assay causes diseases such as cholera, dysentery and typhoid to mention but a few.

Table 1: The geochemical characteristics of spring water resources associated with lignite seams in parts of Orlu, Imo State

	Ihioma		Umuhu Okabia		Ubaha		Mgbede		
Parameters	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**WHO (2006)**
Ph	4.2-4.8	4.5	5.3- 5.8	5.6	5.1- 5.8	5.5	6.5-6.9	6.7	6.5-9.0
Electrical conductivity (µS/cm	55-64	60.5	52- 55	52.3	68- 76	73	35- 45	40	1,400
TDS (mg/l)	31-38	35.4	38-45	42	48-54	50.3	21- 26	24	1,500
Ca^{2+} (mg/l)	2.2-2.8	2.51	2.5-3.2	2.80	2.8-3.5	3.2	6.1-7.4	6.5	200
Mg^{2+}(mg/l)	0.90-1.4	1.10	0.87-1.10	0.90	1.0-1.4	1.20	0.74-0.94	0.80	150
Na^{+}(mg/l)	7.5-8.9	8.5	7.2-8.4	7.8	6.4-7.4	7.0	3.2-4.0	3.60	500
K^{+}(mg/l)	0.20-0.60	0.40	0.25-0.50	0.30	0.35-0.67	0.50	0.80-1.30	1.00	50
HCO_3^{-}(mg/l)	15-18.4	16.2	13.8-16	14.5	14-18	15.0	19-25.1	22	500
SO_4^{2-}(mg/l)	2.4-3.3	3.0	2.4-3.1	2.70	2.1-2.80	2.40	4.0-5.0	4.60	400
Cl^{-}(mg/l)	8.9-12	10.50	8.6-11	9.40	9.8-12.5	11	3.5-4.7	4.0	500
NO_3^{-}(mg/l)	0.01-0.05	0.03	0.01-0.04	0.02	0.02-0.07	0.04	0.20-0.90	0.40	40-70
Total iron(mg/l)	11.9-19	15	14-23	16.5	17-24.7	20.20	0.01-0.06	0.03	0.03-1.0
Zn^{2+}(mg/l)	0.02-0.07	0.04	0.03-0.09	0.06	0.03-0.08	0.03	0.01-0.05	0.02	5.0
Pb^{2+}(mg/l)	Nd		Nd		Nd		Nd		0.05
Cu^{2+}(mg/l)	Nd		Nd		Nd		Nd		1.00
Mn^{+}(mg/l)	Trace		Trace		trace		0.002-0.007	0.004	0.01-0.20
Total organic carbon (mg/l)	3.4-5.0	4.7	3.6- 4.9	4.4	3.2-5.3	4.8	Nd		5
Total coli form cfu/100ml	1.5-4.0	2.0	2.0-6.0	4.0	5.0-7.0	6.0	6.5-10	8.0	10.0

6.0 Conclusion

The physical and bio-chemical analyses of the springs (Ihioma, Umuhu Okabia and Ubaha) located within the Ogwashi-Asaba Formation indicate that they are characterized by low pH, high concentrations of iron and significant total organic carbon (TOC). However all the measured parameters in Mgbede spring located within the Ameki Formation fall within WHO (2006) drinking water standard. The low pH and significant levels of total iron and TOC of the springs located within the Ogwashi-Asaba Formation are attributed to the lignite seams and associated pyrites. This implies that the lignite deposits have serious impact on the quality of the spring water in terms of hydrogen ion (pH), total iron and total organic carbon concentrations. The pH of the sprigs can be treated using sodium bicarbonate (soda ash) while the microbial character of the springs can be improved upon by chlorination while iron can be treated using aeration method.

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Table 2: Concentrations of major cations and anions of the spring resources in milliequivalent/liter and % , epm.

	Concentrations (Meq/l)					% , epm			
Parameters	**Equivalent mass**	**Ihioma**	**Umuhu Okabia**	**Ubaha**	**Mgbede**	**Ihioma**	**Umuhu Okabia**	**Ubaha**	**Mgbede**
Ca^{2+}	20.0	0.126	0.140	0.160	0.325	21.20	25.0	27.9	56.9
Mg^{2+}	12.2	0.090	0.074	0.098	0.065	15.10	13.2	17.1	11.4
Na^{+}	23.0	0.369	0.339	0.304	0.156	62.00	60.5	53.0	27.3
K^{+}	39.1	0.010	0.007	0.012	0.025	1.70	1.3	2.0	4.4
	Total	0.595	0.560	0.574	0.571	100.00	100.0	100.0	100.0
HCO_3^{-}	61.0	0.265	0.237	0.246	0.361	42.30	42.5	40.6	52.7
SO_4^{2-}	48.0	0.065	0.056	0.050	0.096	10.40	10.0	8.3	16.7
Cl^{-}	35.5	0.295	0.265	0.309	0.113	47.10	47.5	50.9	19.6
NO_3^{-}	62.0	0.001	0.000	0.001	0.006	0.20	0.0	0.2	1.0
	Total	0.626	0.558	0.606	0.576	100.00	100.0	100.0	100.0

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Table 3: Sodium Adsorption Ratio (SAR) Of The Springs

	Ihioma	Umuuhu Okabia	Ubaha	Mgbede
Sar	1.12	1.05	0.85	0.36
Remarks	Excellent	Excellent	Excellent	Excellent

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