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Research Article

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Geochemical Analysis of Groundwater Contamination around the Umueze-Ibeku Dumpsite

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Abstract Umueze-Ibekuis located between Latitudes 5.54608° and 5.56128° and Longitudes 7.49625° and 7.49822° with elevations between 135m and 130m above mean-sea level. Considering the risk posed by contaminated groundwater to community health, water quality assessment was conducted for 5 boreholes and a stream, and analysed in the Laboratory. pH and Electrical Conductivity were measured in-situ. Results were modelled using Surfer 13 and Excel spreadsheet. 20 parameters were analysed in each water sample. Results show that B5 & B1 have Total hardness values of 210Mg/l and 200Mg/l which are above WHO/NIS standard. B6 and Stream have highest values of lead (0.017Mg/l and 0.03Mg/l respectively) which are above the limit of 0.01Mg/l. Their Mercury concentrations are0.003Mg/l and 0.002Mg/l respectively being higher than permissible limits of 0.001Mg/l. Stream has unacceptable Mn concentration of 0.558mg/l. Microbial count for all samples exceeds WHO and USEPA limit of $1.0x10^2$ cfu/ml & $5.0x10^2$ cfu/ml respectively. Stream and B6 have the highest values of $3.8x10^5$ cfu/ml and $2.7x10^5$ cfu/ml respectively. Some pathogens identified as microbial isolates include salmonella, E-Coli, bacillus, Kiesbiella, enterococcus and Enterobacter. Therefore, persons who consume water from any of these sources run the risk of health problems such as pneumonia, diarrhoea, nausea, nervous system disorders and lots more.

Keywords Contaminants, geochemical, groundwater, Umueze-Ibeku, quality, water

Introduction

Water is needed for sustenance of human life and existence [1]. Adequate supply of quality water is a major prerequisite of everyday activity and a major requirement for any sustainable development programme [2]. It is an important landscape element which is mobile and chemically active, being in continuous motion through the earth crust [3]**.** In the world over, ground and surface water are the major sources of water for domestic, agricultural and industrial uses. Ground water is majorly accessed through water boreholes and deep wells. Groundwater abstraction has gained significant acceptability in Nigeria due to the increasing need for potable water, particularly in places where there is limited access to rivers and streams [4].

However, the relevance of water for domestic use is dependent on its quality. Quality water supply in Africa leaves a lot to be desired as most urban areas lack adequate access to this amenity. According to [5], about 300 million rural people in sub-saharan Africa have no access to safe water supplies. In Nigeria, Potable water supply like in other developing countries is facing serious challenges [6]. As such, discussion on water quality is necessary considering the vulnerability of water (rain, surface and ground water) to contamination. The presence of pollutants in water violates its originality. [7] perceives water quality to involve the physical, chemical, pathogenic and radiological properties of water. It describes the state of the resource relative to the needs of man. In Nigeria and Abia state in particular, boreholes have become a major source of drinking water. As such the need to protect groundwater quality is of prime importance to the wellbeing of man.

In a bid to ensure access to quality water, organizations such as the World Health Organization (WHO), United States Environmental Protection Agency (USEPA), European Union (EU), Nigeria Industrial Standard (NIS), National Food Drug Administration and Control (NAFDAC) etc established standards to govern drinking water provision and usage. A violation of these standards and water quality regulations exposes consumers to various health risks. Human (anthropogenic) activities such as Industrial activities, agricultural activities, solid waste disposal system, geologic subsurface formations and sewage are major contributors to groundwater pollution [8].

The aim of this study is to ascertain quality of the groundwater and invariably its suitability for drinking, towards ensuring the protection of the health of users.

Location of the study area

The study area is Umueze-Ibeku located between Latitude 5.54608° and 5.56128° and Longitude 7.49625° and 7.49822° with elevations of between 135m and 130m above mean sea level along the Umueze-Agbor-Ubani road.

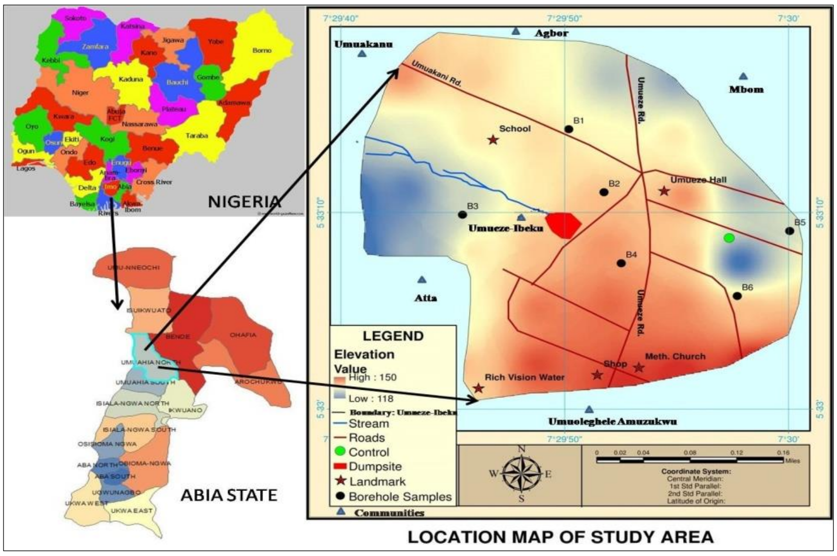

Figure 1: Location Map of Umueze-Ibeku showing the Water Sample points

Materials and Methods

Materials used in this study include E-1 Portable TDS & EC Meter, pH-618 Pen-Type Automatic Correction pH-meter, Water sampling kits, laboratory test kits, and Handheld GPS. Computer Software used for modelling and analysis include Surfer 13, Microsoft Word and Excel spreadsheet.

Laboratory and in-situ tests, and analysis were conducted on six water samples with twenty (20) physicochemical properties and heavy metals analysed. These parameters include: Temperature, Total Dissolved Solids (TDS). pH, Electrical Conductivity (EC), Total Hardness (TH), Dissolved Oxygen (DO), Sulphates (SO_4), Nitrates (NO_3), phosphate (PO_4), Chlorine (Cl), Potassium (K), Lead (Pb), Mercury (Hg), Zinc (Zn), Manganese (Mn), Magnesium (Mg), Calcium (Ca), Iron (Fe), Total Microbial Count and microbial isolates.

Water samples were taken to the Soil, Plant and Water Analysis Laboratory of Federal Ministry of Environment in Umuahia, Southeastern Nigeria for analysis. However, in situ data acquisition was conducted for properties such as pH and Electrical Conductivity. This is necessary because these parameters change easily when exposed to the atmosphere as atmospheric gases can dissolve into the water, including heat transfer which can alter ambience [9]. Meanwhile other parameters were analysed in the laboratory. The NIS, NAFDAC and WHO standards were culled from [10], [11], [12] and [13].

Results and Discussion

Results

Result of water quality analysis conducted on five (5) borehole water and one (1) stream water samples are as presented below vis-a-viz standards such as NIS, NAFDAC and WHO. A total of 20 parameters were analysed.

Table 1: Result of Geochemical Analysis of Borehole/ Stream water samples

Parameters	B1	B2	B3	B5	B6	Stream	NIS-2015 (GW)	NAFDAC	WHO
pH	7.5	6.46	7.55	6.25	7.23	8.22	7.0 -8.5	6.5-8.5	6.5-8.5
Temp (°C)	27.3	26.8	26.7	27	25.7	29.2	Ambient	27	23
EC (µS/cm)	188	122	274	716	54	174	1000	-	1000
TDS (mg/l)	125.96	81.74	183.58	479.72	36.18	116.58	500	500	500
Turbidity (FAU)	0.001	0.002	0.997	0.806	1.965	8.229	5	-	5
Hardness (Ca $C0_3$) Mgl	200.00	30.00	110.00	210.00	100.00	160.00	100	-	100
DO (mg/l)	0.44	0.54	0.61	0.56	0.73	2.65	-	-	4
NO_3 (mg/l)	0.84	0.98	0.70	1.38	1.14	0.09	45	10	50
PO_4 (mg/l)	0.339	0.276	0.112	0.582	0.791	1.824			
Cl (mg/l)	39.00	35.50	56.72	95.72	31.91	21.27	250	100.00	250
Ca (mg/l)	52.10	8.02	28.06	48.10	28.06	40.10	75	75.00	75
Mg (mg/l)	17.02	2.43	9.73	19.46	7.30	14.60	30	20.00	50
K (mg/l)	0.441	0.440	0.454	0.484	0.489	0.615			
$S0_4$ (mg/l)	0.735	0.711	0.831	0.876	1.161	1.905	200	100.00	250
Pb (mg/l)	0.003	0.001	0.008	0.009	0.017	0.030	0.01	0.01	0.01
Hg (mg/l)	Trace	Trace	0.001	0.001	0.003	0.002	-	-	0.001
Fe (mg/l)	0.011	0.003	0.073	0.042	0.113	0.214	0.1	0.30	0.3
Zn (mg/l)	0.006	0.005	0.001	0.012	0.014	0.019	5	5.00	5
Mn (mg/l)	0.017	0.045	0.031	0.000	0.048	0.558	0.05	-	0.1
Microbial Count (CFU/ml)	4.8×10^3	2.65×10^3	6.3×10^4	4.4×10^3	2.7×10^5	3.8×10^5			100
Microbial Isolates	*Bacillus Spp, Salmonella Spp, Pseudomonus Spp, Klebsiela Spp, Enterococilica Spp*	*Pseudomonus Spp, LactobacillusSpp, Salomonella, Bacillus Spp.*	*Micrococcus Spp, E. Coli, Bacillus Lactobacillus, EnterobactaSpp, Salmonella, Streptocacocus Spp.*	*Lactobacillus, Micrococlus Spp, Lactobacellus Spp, Pseudomonus Spp.*	*Salmonella, E.Coli, Bacillus Spp, Salmonella Spp, Enterococilic Spp, Lactobacillus.*	*Klebsiela Spp, Salmonella, Bacillus Spp, Enterococilic Spp*			

Where: Electrical Conductivity = EC, Total Dissolved Solids = TDS, Red coloured parameters indicate values not within permissible limits

Colour Legend for charts: *Green coloration is for samples within permissible limits, Red is for samples outside permissible limits, and Yellow is for standards*

The distribution of turbidity across water samples as seen in table 1shows increasing water cloudiness in the direction of the stream. A slight decrease can be seen as one moves from B1 to B6 in the NS direction.

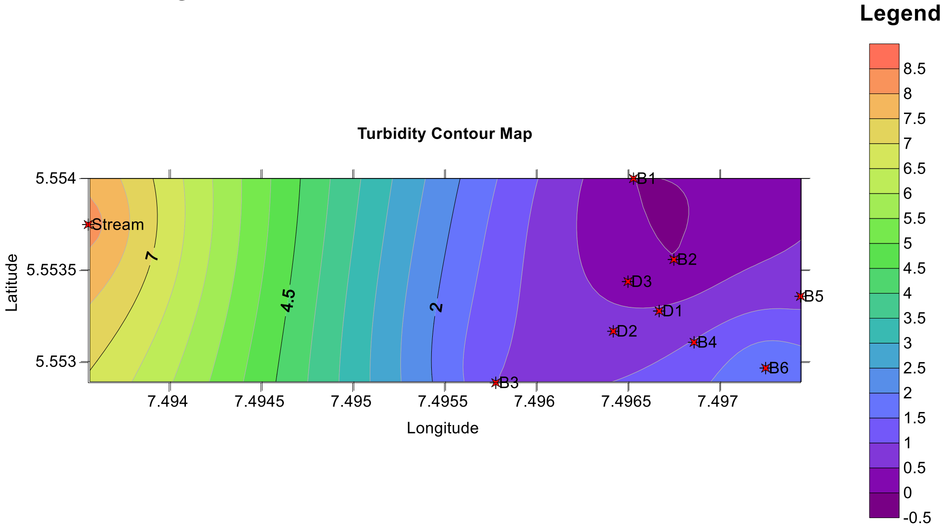

Figure 2: Turbidity Contour Map

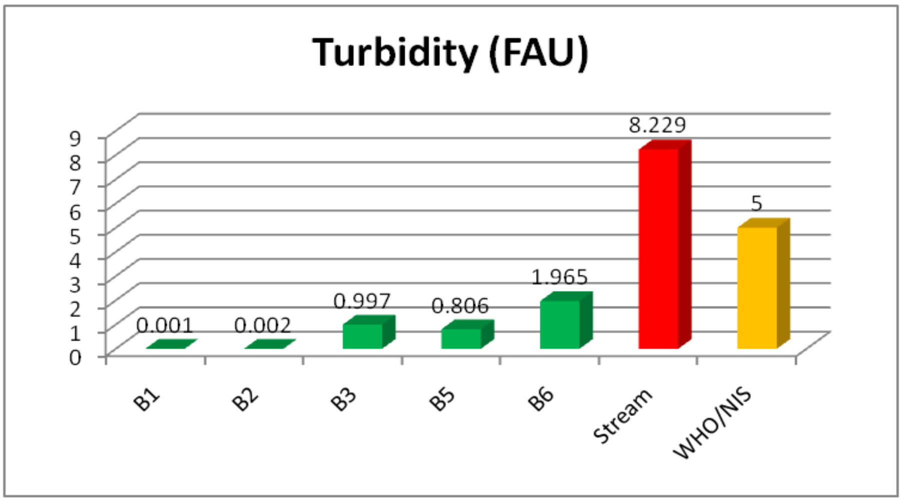

Figure 3: Turbidity Concentration Chart

It is evident from Fig. 3 above that only stream has turbidity value (8.229mg/l) above permissible limit of WHO and NIS which is set at 5mg/l.

Fig. 4 and Fig. 5 presents total hardness distribution and water samples' values viz-a-viz WHO, USEPA and NIS standards for potable water.

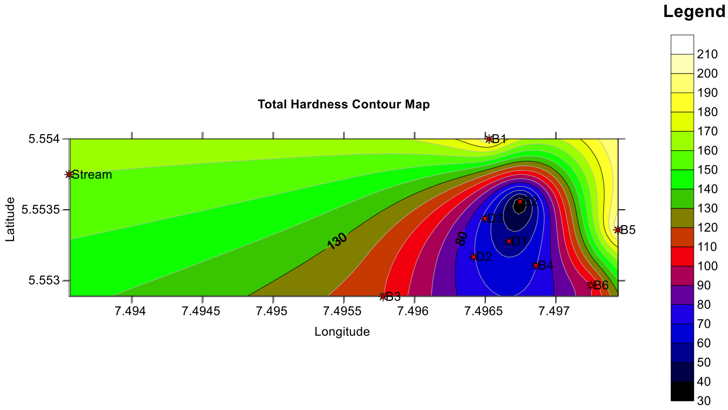

Figure 4: Total Hardness Contour Map

Considering the concentration distribution in Fig. 5, B1, B3, B5 and Stream produce hard water. This affects their aesthetic values because of the presence of $CaCO_3$. Hardness of water can also have economic implication as soap does not form lather easily.

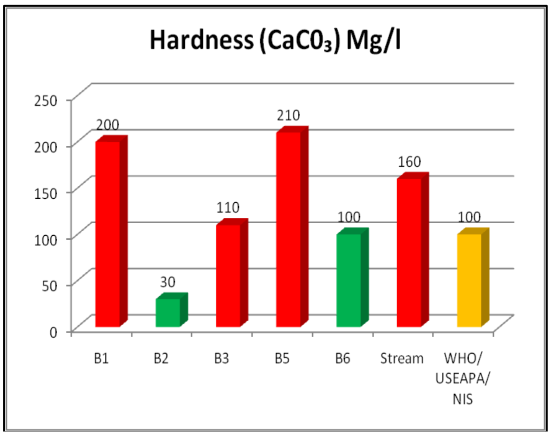

Figure 5: Total Hardness Concentration Chart

Mercury is a heavy metal; its presence above acceptable limit is a threat to human life. Fig. 6 gives the concentration distribution of Hg around sample water sources. Unacceptable concentration of Hg is found in the SE and Western wing of the area. Hence, the Stream and B6 have higher values above WHO and NIS standards of 0.001mg/l as seen in Fig. 7.

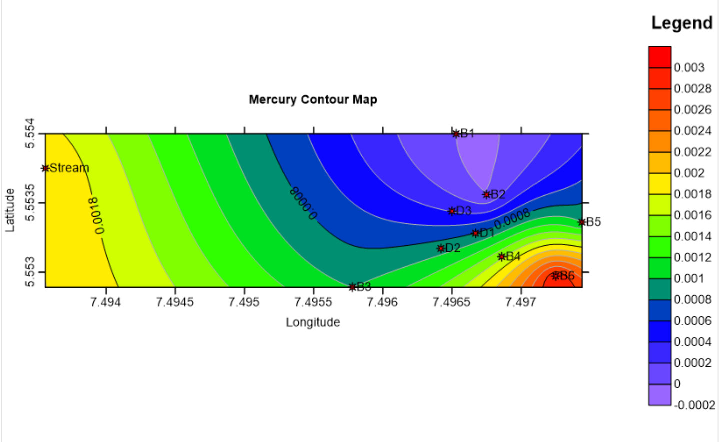

Figure 6: Mercury Contour Map

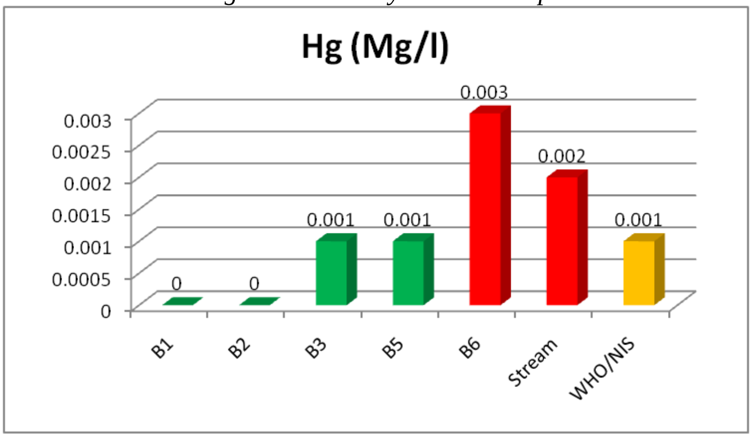

Figure 7: Mercury Concentration Chart

Another heavy metal of concern is Lead (Pb). Fig. 8 presents its concentration distribution. It typifies the distribution pattern of Mercury.

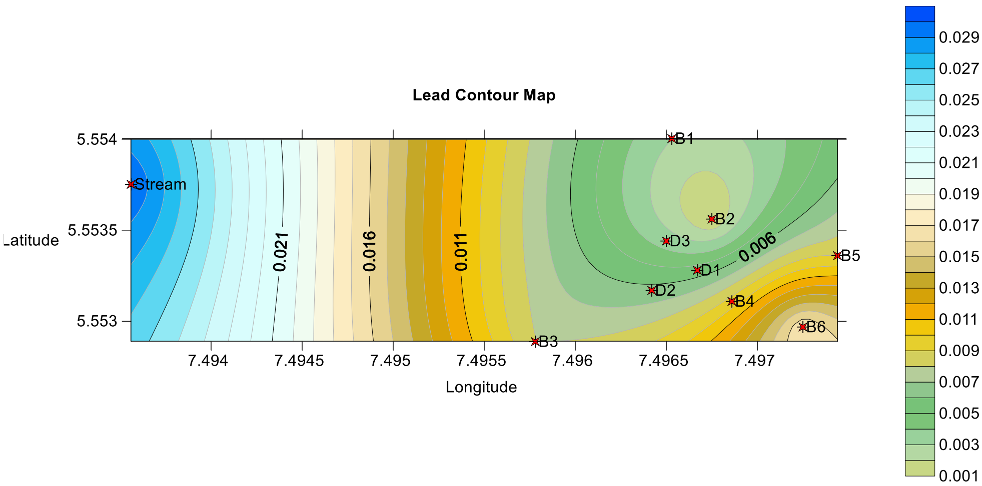

Figure 8: Lead Contour Map

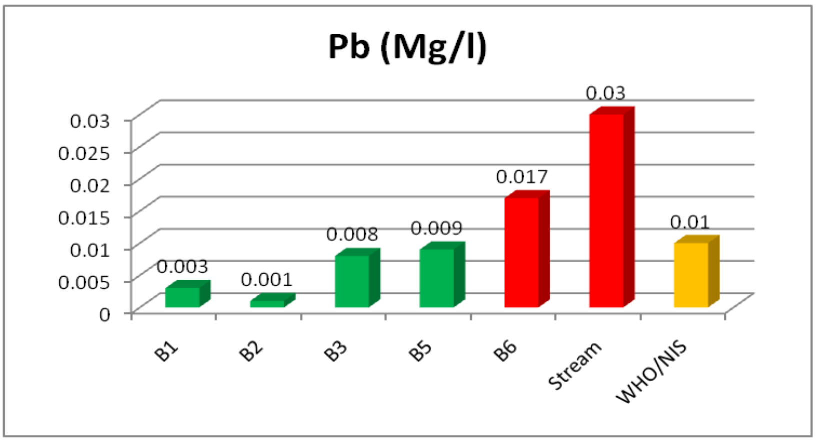

Figure 9: Lead Concentration Chart

As seen in Fig. 9 above, B6 and Stream have concentrations above the WHO/NIS standard of 0.01mg/l. This speaks of the high risk associated with consuming water from these sources.

Manganese (Mn) is another heavy metal found within the area of study. Unlike Pb and Hg, its distribution pattern in Fig. 10 shows higher concentration in the NE and Western direction of the area.

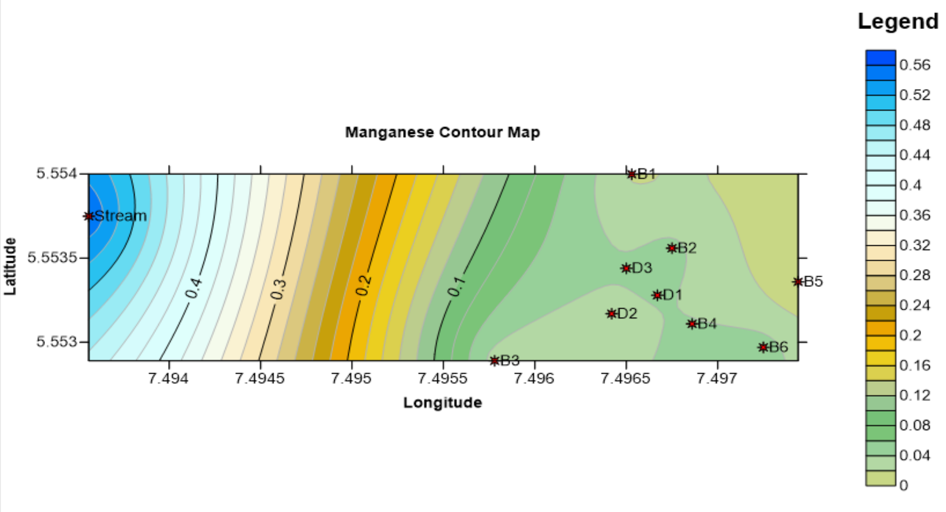

Figure 10: Manganese Contour Map

Hence, the Stream alone was found to contain unacceptable concentration of Mn (0.559mg/l) as presented in Fig. 11 below. This is above the WHO/NIS limit of 0.1mg/l

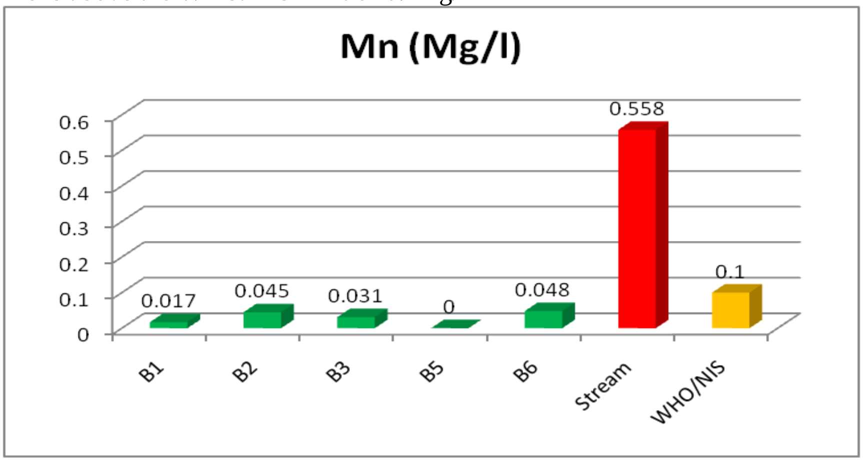

Figure 11: Manganese Concentration Chart

In this research, microbial count presents total number of bacteria present in a millilitre of water sample. The result presented in Fig. 12 triggers a major concern with respect to water quality within the area. As seen, all water samples have microbial loads far above the limit of 500, with B6 and stream in hundreds of thousands.

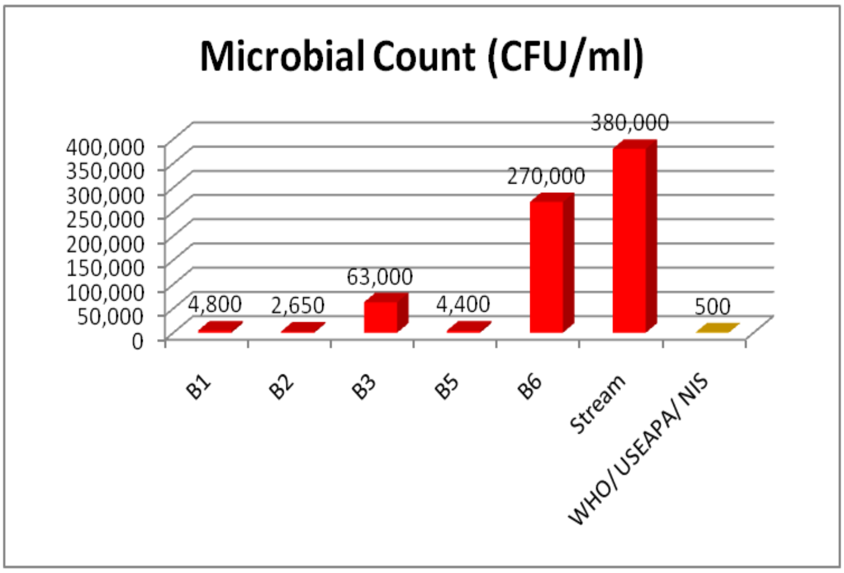

Figure 12: Microbial Count Concentration Chart

Other parameters such as Temperature, Total Dissolved Solids, Electrical Conductivity, pH, Dissolved Oxygen, Sulphate, Phosphate, Chloride, Nitrate, Calcium, Magnesium, Potassium, Iron, Zinc and Carbonate, have concentrations which are within permissible limits.

Discussion

Considering the result of laboratory analysis reflected in table 1, B5 has the highest EC of 716mg/l which is within the WHO/NIS limits of 1000mg/l. Furthermore, B5 has the highest TDS of 479.72mg/l which is within the WHO/NIS limits of 500mg/l. Stream has the highest turbidity of 8.229FAU which is above the WHO/NIS limits of 5FAU. Hence, it is unsafe for consumption. B1, B5 and Stream are hard with B5 & B1 having values of 210Mg/l and 200Mg/l respectively above the standard limits of 150Mg/l& 100Mg/l WHO/NIS respectively. B6 and Stream have the highest value of lead (Pb) (0.017Mg/l and 0.03Mg/l respectively) above the limit of 0.01Mg/l. They also have values of Mercury (Hg) (0.003Mg/l and 0.002Mg/l respectively) being higher than permissible limits of 0.001Mg/l for drinking water. Having Pb & Hg concentrations higher than permissible limits renders water from B6 unfit for consumption. Stream has Mn concentration of 0.558mg/l which is above the limit of 0.3mg/l. The total bacterial counts (TBC) for all the water samples were generally high ranging from 2,650cfl/ml to 380,000cfl/ml exceeding the WHO limit of 100cfu/ml for drinking water [14]. The high total count is indicative of the presence of high organic and dissolved salts in the water [15]. The WHO standard for Total Coliform Count (TCC) and Feacal Coliform Count (FCC) is not more than 10 cfu/ml, while microbial count limit for USEPA is 500cfu/ml. In line with result on table 1, all water samples have microbial count more than $1.0x10^2$cfu/ml which is indicative of high bacterial load exceeding acceptable limits. Stream and B6 have the highest values of $3.8x10^5$cfu/ml and $2.7x10^5$cfu/ml respectively while B2 have the least with $2.65x10^3$cfu/ml. This raises issues with portability of all water samples. Result of microbial isolates from the analyzed water samples show that all samples except B5 have salmonella while B3 and B6 have E. Coli. All water samples contain bacillus, while B1 and stream contain Kiesbiella. Enterococcus was found in B1, B6 and stream while enterobacter was detected in B3. Water from a source is considered non-potable if at least one faecal parameter is present in it.

In the work of [16] which applied Electrical Resistivity Tomography (ERT) to investigate leachate production by the Umueze-Ibeku dumpsite located at an average distance of not more than 150m from all sampled boreholes. It was discovered that leachate produced by the dump has penetrated a depth of 11.35m (not up to the aquifer depth to be responsible for water contaminations). Hence, contamination of water samples by high microbial load could be from household septic tanks whose distances from sampled boreholes are less than the 50ft approved by WHO as minimum distance.

In summary, parameters of concern to the quality of borehole water samples are total hardness, Mn, Pb, and Hg and pathogenic organisms. Community members who consume any or a combination of the borehole waters run the risk of exposure to health problems such as memory & learning disorders, diarrhoea, kidney damage, meningitis, etc.

Conclusion

Geochemical analysis conducted show that all borehole water samples are contaminated with more of pathogenic organisms as indicated by the high microbial count and harmful isolates. The presence of pathogenic contaminants can be attributed to nearness of boreholes to residential septic tanks (less than 50ft WHO standard). Physicochemical contamination is in B6 and Stream with high concentration of lead (Pb) and Mercury (Hg).

The harmful effects of identified pathogenic contaminants in sampled borehole include pneumonia, diarrhoea, nausea, and lots more. Community members who consume water from these boreholes have high predisposition to these illnesses which can take a toll on their health, livelihoods, finances, and community wellbeing in general.

Acknowledgment

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