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Assessment of Groundwater Quality around a Cement Factory in Ewekoro, Ogun State, Southwest Nigeria

A.O. DAVID, O.T. OPAFOLA, O.O. AKISANYA,
D.O. OLAWOMO, D.A. KADIR
Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.

Abstract. Samples of groundwater from hand dug wells and boreholes in Ewekoro, Ogun State and its environs were collected and analysed for various physicochemical parameters and some metal ions such as lead, copper, iron, manganese and zinc. Also, an independent sample test of the wells and boreholes close to the Cement Factory around that area was carried out. The qualities of groundwater were determined by investigative study which involved the determination of some heavy metals and physicochemical properties in drinking water samples. Eight (8) samples of ground water were collected from the eight sampling sites. The samples were analysed for the following parameters; iron, copper, manganese, zinc, lead, color, dissolved solids, electrical conductivity, pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), temperature, turbidity and total hardness using standard methods. The test results showed the variation of the investigated parameters in the samples as follows: temperature 26-31ºC, pH 5.9-7.2, electrical conductivity (EC) 0.37 – 0.78 µS/cm, total hardness 181.8 – 333.0 mg/l, turbidity 0.00-0.05 FTU, colour 5-10 TCU, dissolved oxygen 4.31-5.01 mg/l, BOD 0.2-1.0 mg/l, COD 2.0 -4.0 mg/l, Cu 0.04 – 0.09 mg/l, Fe 0.006-0.122 mg/l, Zn 0.016-0.306 mg/l, Mn 0.01-0.05 mg/l and Pb < 0.001 mg/l. The concentrations of some of the investigated parameters in the drinking water samples from the research region were above the permissible limits of the World Health Organization standard for drinking water quality guidelines. The dissolved oxygen was found to exceed 5.0 mg/l which is the WHO permissible limit, Also Limestone was found to exceed the WHO maximum limit of 170 mg/l. All the above results confirmed the high pollution of the ground water sources and hence, they are not suitable for consumption without any prior treatment.

Keywords: Groundwater, Quality, Heavy metals, parameters.

1. Introduction

Groundwater and surface waters are critical sources of water for human existence and industrial development around the world. The composition of the recharge components, as well as geological and hydrological fluctuations within the aquifers, regulates the chemistry of ground and surface water [1]. The spread of epidemics and chronic diseases in humans is caused by contaminated groundwater and surface water sources. The loss of our groundwater resources is due to industrialization and population growth [2]. Understanding and evaluating the suitability of groundwater for various applications require more knowledge. For ultimate application and management, knowledge of water-rock interaction as well as anthropogenic influence is required. Groundwater quality refers to the physical, chemical, and biological characteristics of the water [3]. Physical water quality parameters include temperature, turbidity, colour, taste, and odour. The chemical properties are an issue because most groundwater is colourless, odourless, and tasteless. Mineral ions are naturally present in groundwater, and as the water flows through mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer, these ions progressively dissolve from soil particles, sediments, and rocks. Some of the dissolved solids could have come from rainwater or river water that recharges the aquifer. However, human activities such as mining, the discharge or spread of chemicals and microbiological matter at the land surface and into soils, and the injection of pollutants directly into groundwater can all alter the natural composition of groundwater.

Cement plants are notorious for releasing a lot of dust into the environment. Emitted dust is naturally removed from the earth's surface as deposits in the form of dry or wet deposition during rainfall [4]; [5]. The harmful effects of dust fall, which is characterized by enriched toxic heavy metals such as arsenic (As), lead (Pb), nickel (Ni), chromium (Cr), copper (Cu), zinc (Zn), manganese (Mn), and cadmium (Cd), on the soil, flora, and fauna of the cement factory neighbourhood, could be significant [6]; [7]

Water can be contaminated with contaminants regardless of the form in which it is found. As a result, water quality analysis is a critical issue that must be addressed. These wastes (pollutants) degrade the natural quality of the environmental media (air, water, and land), impacting plant, animal, and human life. Because of the evidence of heavy metal toxicity to human health and biological processes, water pollution by heavy metals has become a major public and scientific problem [8]. The factory's dust emissions have harmed not only the environment but also the water in open wells, which has been contaminated by cement dust deposition. Residents of the neighborhood surrounding the cement mill rely on these wells for drinking water and other household needs. This should be cause for worry because cement dust penetration may cause unwanted changes in water quality. Water quality has an impact on people's health, thus testing water for physical, biological, and chemical qualities, as well as trace element levels, is critical for public health investigations [9]. Furthermore, according to [10], cement dust can change the salt content of water, causing major disruption of aquatic populations as well as lowering the quality of water used for drinking. As a result, the existing state of the groundwater near the cement factory necessitates research to assess the health risk to individuals who rely on groundwater for drinking and other domestic purposes.

2. Research Methodology

2.1 Materials

2.1.1 Sample Collection

The procedures for determining water quality are varied and intricate. These procedures are similar to a chain of roughly a dozen links, and the failure of any one of them can compromise the entire evaluation. As a result, creating a one-of-a-kind operation necessitates a careful evaluation of the water quality assessment's particular goals. Groundwater samples from hand-dug wells and boreholes in the industrial regions were gathered for this investigation. A 2.5L keg was used to collect samples for physical and chemical examination, and ice packs were used to keep them cold.

2.2 Methods

2.2.1 Preparation of Aqueous Stock Solutions

All chemicals used are of analytical grade. All solutions used for this analysis were prepared by dissolving the appropriate amount in distilled water. Distilled and deionized water were used to prepare the solutions.

2.2.1.1 Iron Solution

Iron $FeCl_3.6H_20$ (0.483g) was weighed and dissolved in distilled water in a volumetric flask.
Thus gives a specific amount of standard solution.

2.2.1.2 Copper Solution

This was prepared by dissolving an amount of $Cu(NO_3)_2.3H_2O$ (0.5g) in concentrated HNO_3 to make up 1000.00 cm^3 with distilled water giving 1000.00mg/l copper solution.

3. Result and Discussion

3.1 Physicochemical Parameters

Tables 1 and 2 present the results of the physicochemical parameters analysis for hand-dug wells and borehole water samples from Ewekoro. Each table compares the concentration of the physicochemical parameters to the WHO standard for drinking water as well as the Nigerian Standard for Drinking Water.

3.2 Heavy Metals Comparison in Water Samples

Figures 4.2 shows, the comparison of copper, iron, lead, zinc and manganese metals concentrations in the water samples to the maximum limit set by WHO/SON.

3.3 WHO Standard for Heavy Metals

Table 3 shows WHO standard for heavy metals.

3.4 Sample locations and Elevations

Table 4 shows the longitude and latitude of the sample sites and their elevation away from the midpoint

Table 1: Values of physicochemical parameters (Non-metals) for wells and borehole water samples compared with WHO standard and SON for the sample site

S/N	Parameters	WHO	SON	S1, North HW	S2, North HW	S1, West HW	S2, West HW	S1, South BH	S2, South BH	S1, East HW	S2, East HW
1	Temp	**30.0**	**30.0**	31.0	30.0	**29.0**	**29.0**	**26.0**	**27.0**	**28.0**	**28.0**
2	**pH**	**6.59.5**	**6.58.5**	7.0	7.2	7.2	6.2	6.7	5.9	6.1	5.8
3	**E.Cond(μS/cm)**	**810,000**	1000	0.78	0.69	0.54	0.37	0.70	0.37	0.44	0.48
4	**Turbidity (NTU)**	5.0	5.0	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.01
5	**T. Hard (mg/l)**	**500.0**	150	333.0	**242.4**	**181.8**	**212.0**	**202.0**	**206.0**	**212.0**	**260.0**
6	**D.O (mg/l)**	**5.0**	**5.0**	5.01	4.36	4.80	4.31	4.72	4.40	5.11	4.02
7	**C.O.D (mg/l)**	**10.0**	**10.0**	4.0	2.7	2.0	2.3	2.4	3.1	2.7	3.5
8	**B.O.D (mg/l)**	**3.0**	**3.0**	<1	2	<1	<1	1	<1	1	<1
9	**Colour (TCU)**	**3-15**	15	**10.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**
10	**Limestone**	120-170	120-170	300.3	84.2	263.9	91.0	227.5	81.9	82.0	63.7
11	**D.S (mg/l)**	**500.0**	500	**103.5**	**73.7**	**61.4**	**50.5**	**45.8**	**53.1**	**73.7**	**45.8**

Table 2: Values of physicochemical parameters (Metals) for wells and borehole water samples compared with WHO standard and SON for the sample site

S/N	Parameters	WHO	SON	S1, North HW	S2, North HW	S1, West HW	S2, West HW	S1, South BH	S2, South BH	S1, East HW	S2 East HW
1	**Cu (mg/L)**	**2.0**	1.0	**0.09**	**0.06**	**0.04**	**0.05**	**0.09**	**0.09**	**0.07**	**0.06**
2	**Fe (mg/L)**	**0.3**	**0.3**	0.006	0.007	0.051	0.122	0.051	0.009	0.005	0.007
3	**Zn (mg/L)**	**4.0**	**3.0**	0.306	0.135	0.016	0.108	0.197	0.158	0.285	0.127
4	**Pb (mg/L)**	**0.01**	**0.01**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
5	Mn (mg/L)	**0.1**	**0.2**	**0.05**	**0.03**	**0.01**	**0.03**	**0.02**	**0.03**	**0.02**	**0-01**

Table 3: WHO Standard for Heavy Metals

S/N	**Metals**	Highest desirable limit (mg/l)
1	**Copper**	**2.000**
2	**Iron**	**0.300**
3	**Manganese**	**0.100**
4	**Lead**	**0.010**
5	**Zinc**	**4.000**
6	**Nickel**	**0.020**
7	**Chromium**	**0.050**
8	**Cadmium**	**0.030**
9	**Arsenic**	**0.050**
10	**Barium**	**0.050**

Table 4: The longitude and latitude of the sample sites and their elevation away from the midpoint

Location	**Longitude**	**Latitude**	**Elevation**
North 1	N 06□ 53’ 853’’	E 003□ 12’ 179’’	37^{m}
North 2	N 06□ 53’ 853’’	E 003□ 12’ 227’’	37^{m}
South1	N 06□ 53’ 645’’	E 003□ 12’ 036’’	46^{m}
South2	N 06□ 53’ 464’’	E 003□ 12’ 975’’	38^{m}
West1	N 06□ 53’ 579’’	E 003□ 12’ 044’’	37^{m}
West2	N 06□ 53’ 436’’	E 003□ 12’ 952’’	37^{m}
East1	N 06□ 53’ 880’’	E 003□ 12’ 144’’	34^{m}

East2	N 06□ 53' 851''	E 003□ 12' 130''	36m

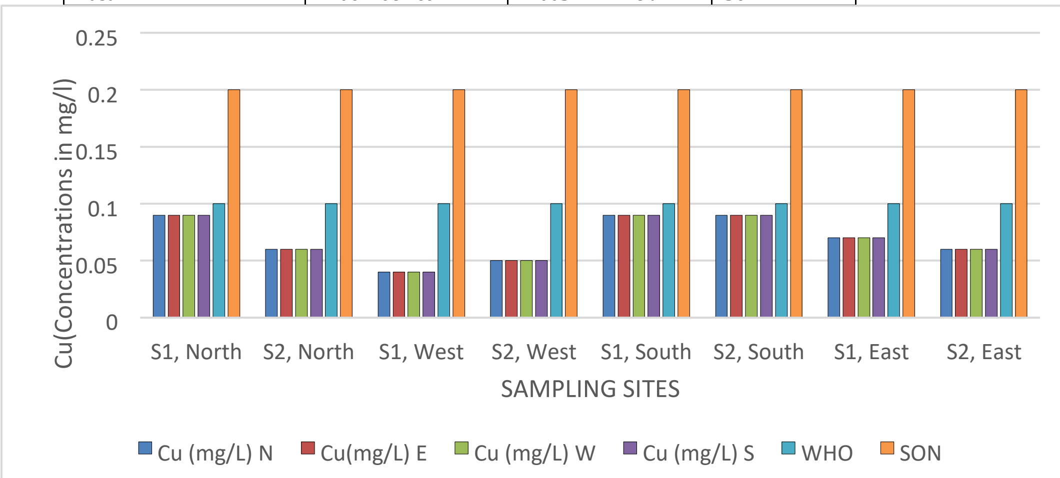

Figure 2: A comparison of the copper concentrations (mg/L) in water samples and the maximum limit set by WHO and SON for the various sampling sites

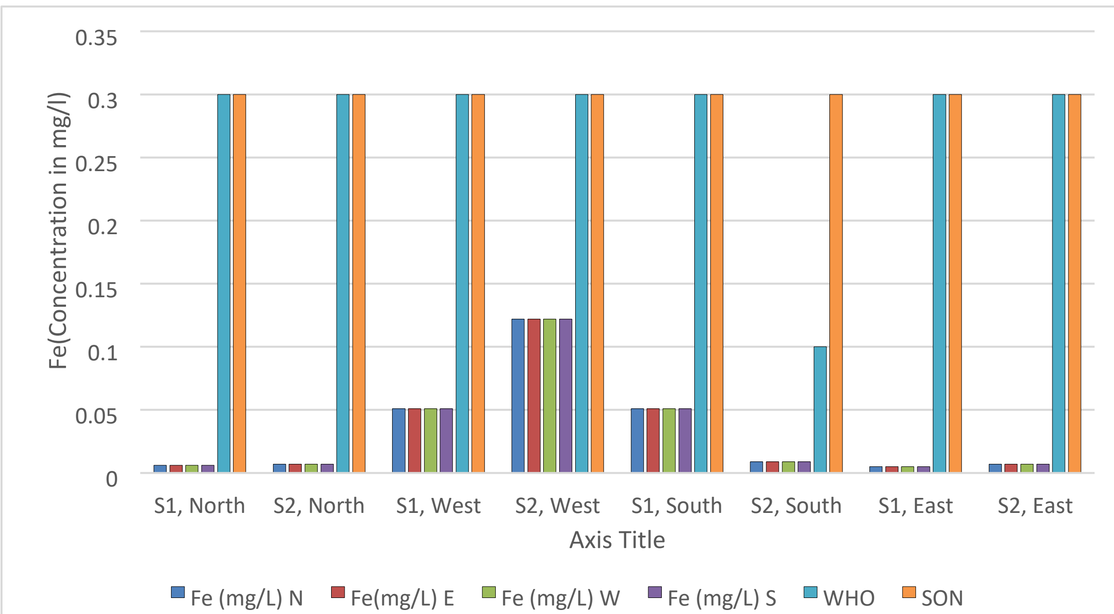

Figure 3: A comparison of the IRON concentrations (mg/L) in water samples and the maximum limit set by WHO and SON for the various sampling sites.

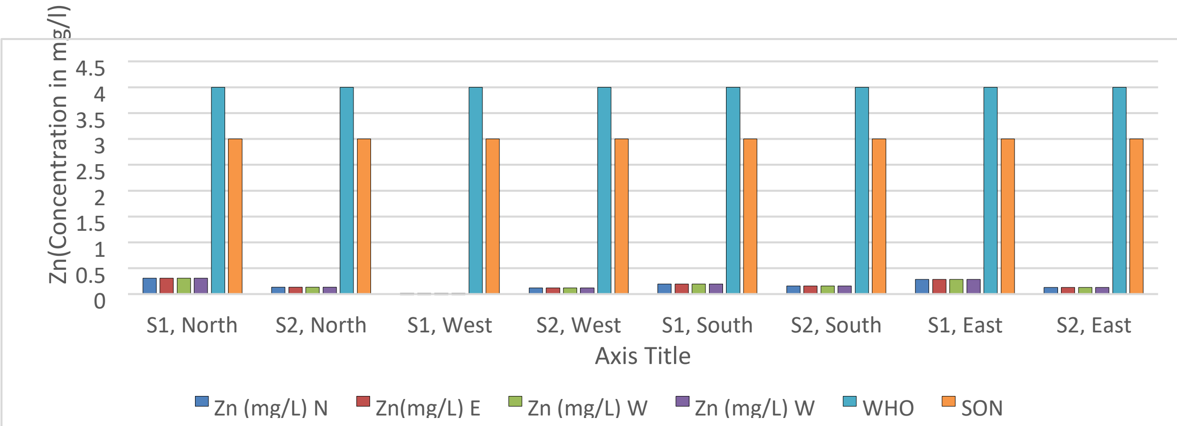

Figure 4 : A comparison of the ZINC concentrations (mg/L) in water samples and the maximum limit set by WHO and SON for the various sampling sites

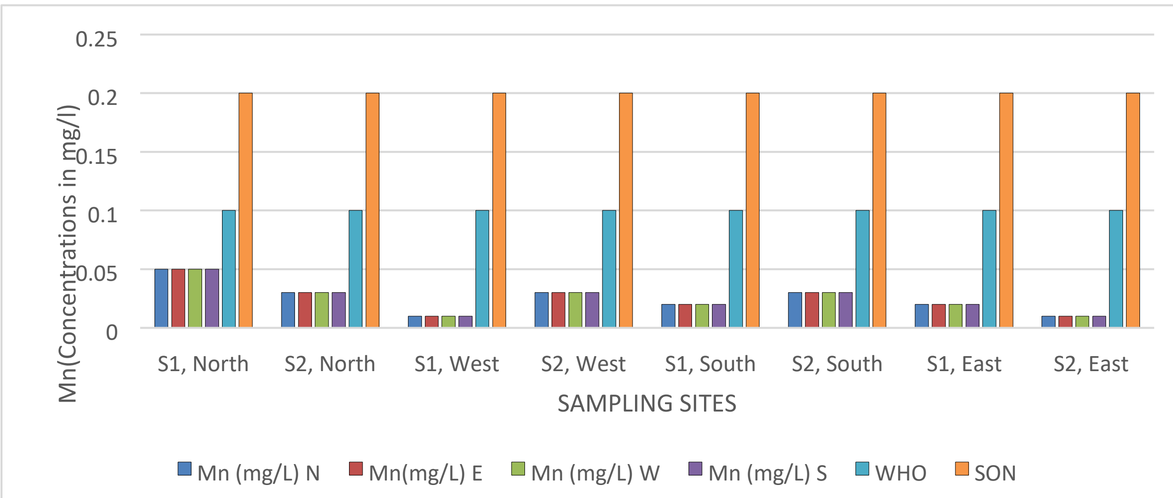

Figure 5: *A comparison of the Manganese concentrations (mg/L) in water samples and the maximum limit set by WHO and SON for the various sampling sites*

The findings of several analyses on the physicochemical parameters of groundwater samples, as well as their comparison with World Health Organization (WHO) standards and the Nigerian Standard for Drinking Water are shown in Tables 1 and 2. The tables present the values of the parameters determined in this study, as well as the recommended standards.

3.5 pH and Temperature

The pH fluctuated between 5.8 and 7.2 pH units. With the exception of samples 1 and 2 from the East of the midpoint, sample 2 from the South, and sample 2 from the West, all other samples were within the WHO portable water range. The pH value indicates that the well waters in the exceptional places are slightly acidic. pH values less than 6.5 are considered too acidic for human consumption and can cause health issues such as acidosis, which can harm the digestive and lymphatic systems. The water temperatures measured at the various sites during the sample period did not differ considerably. Temperatures varied from 26 to 31 degrees Celsius. With the exception of Sample 1 from the North, this could be owing to the sampling season, as ground water pollution may have happened. All other temperature readings are under WHO and SON drinking water limits. Temperature is an important component in aquatic ecosystems because it influences water creatures as well as the physical and chemical properties of water. The results are within the WHO drinking water standard's allowable range.

3.6 Conductivity and Dissolved Solids

The conductivity of the water samples ranged between 0.37 and 0.78 S/cm. All other values fell outside of the WHO regulation range of 8-10,000 µS/cm. The concentration of dissolved solids affects conductivity (DS). TDS can be calculated by multiplying conductivity by a value ranging from 0.55 to 0.75, according to Chapman (1992). Given these low conductivity levels, it's not unexpected that the DS, which measures the amount of dissolved solids in water, is also low. As a result, the DS ranged from 45.8 to 103.5 mg/L for the research. The WHO has not established a health-based value; nonetheless, a DS beyond 1,000 mg/L may be unpleasant to consumers (Amoako *et al.*, 2011).

3.7 Turbidity

The turbidity ranged from 0 to 0.05 NTU. The turbidity of all samples was less than 5.0 NTU. The WHO and SON recommend a turbidity level of 5 NTU in drinking water. Smaller particles, organic materials and dissolved solids, may be responsible for the low turbidity.

3.8 Dissolved Oxygen, Chemical Oxygen Demand and Biological Oxygen Demand

Dissolved oxygen (DO) levels in milligrams/litre ranged from 4.02 to 5.11. The WHO has established a provisional health-based recommendation value for DO of 5.0 mg/L, which should be sufficient to preserve public health (WHO, 1995). Dissolved oxygen (DO) is essential for aquatic organism viability and is also used to determine the degree of freshness of a river. Except for sample 1 from the East, the measured value was lower than the WHO norm.

Very low DO levels can lead to anaerobic conditions, which can generate foul odors in water. Low DO levels can be caused by decomposing organic matter, dissolved gases, industrial waste, mineral waste, and landfill leachate. Chemical oxygen demand (COD) is one of the water quality metrics used to determine a water resource's oxygen consumption potential. The COD levels in the water samples ranged from 2.0 to 4.0 mg/L. All samples from the sites were found to be below the WHO's maximum permitted value of 10 mg/L. The test is often used to assess the amount of organic compounds in water in an indirect manner. COD is a helpful indicator of water quality since most uses of COD quantify the quantity of organic contaminants detected in surface water (Clair, 2003) Biological oxygen consumption: The minimum and highest values for biological oxygen demand derived from hand dug wells and borehole water samples at the four distinct study sites range from (0.2-2.0mg/L) in Tables 1. WHO determined that they were below the maximum allowed amount (3 mg/L). The amount of oxygen required by microbes to stabilize physiologically oxidizable materials is represented by the BOD.

3.9 Total Hardness

The minimum and maximum total hardness values collected from hand dug wells and borehole water samples at the four distinct sampling sites in Ewekoro and its surrounds, as shown in Table 1, were 181.8 – 333.0mg/L, which is less than the WHO (500 mg/L) acceptable limits for drinking water.

3.10 Color

The minimum and maximum values for color obtained from the hand dug wells and boreholes water samples at the four different sampling sites in Ewekoro and its environs shown in Table 1 were 5 – 10 TCU which is below the WHO (3–15TCU) permissible limits for drinking.

3.11 A Comparison of the Concentrations of Metal ions in Water and WHO Maximum

3.11.1 Permissible Limit

The results obtained for the concentrations of metals ions (Cu, Mn Fe, Pb and Zn) in the Water samples collected from different hand dug wells and boreholes, was compared with the WHO maximum permissible limit. The results are presented as a bar chart in chapter four.

3.11.1.1 Copper

The concentrations of copper obtained from the hand dug well sand boreholes water samples at the different sampling sites in Ewekoro as shown in Table 2, ranges from 0.04 mg/L to 0.09 mg/L. The maximum permissible limit by WHO is (2.0 mg/L). Copper is an essential nutrient, but at high dosage, it has been shown to cause stomach and intestinal distress, liver, kidney damage, and anemia (US EPA, 2003).

3.11.1.2 Iron

Because iron is ubiquitous in many aquifers and is found in trace amounts in almost all sediments and rock formations, most groundwater contains some iron. The iron concentrations obtained from hand dug wells and borehole fluids at the several sampling sites in Ewekoro range from 0.006 mg/L to 0.122 mg/L, as shown in Table 2, WHO's maximum allowable value for iron is 0.3mg/L.

3.11.1.3 Manganese

The concentration of manganese metal ions obtained from hand dug wells and borehole waters at the various sampling sites in Ewekoro, as shown in Table 2, ranges from 0.01-0.05mg/L, which is lower than the WHO maximum permissible limit (0.10mg/L). Manganese imparts a bitter taste to water, stains cloths and metal parts, and precipitates in foods when used for cooking, and it also promotes algae growth in reservoirs.

3.11.1.4 Zinc

At a taste threshold concentration of roughly 4mg/litre, zinc imparts an unpleasant astringent flavor to water (as zinc sulphate). The levels of zinc metal ion obtained from hand dug wells and borehole water samples at the sampling sites in Ewekoro range from 0.016 to 0.306 mg/L, as indicated in Table 2 whereby WHO's maximum allowable value is (4.0 mg/L). The level of dissolved zinc in water may increase as the acidity of the water increases; swallowing large levels of zinc can cause stomach cramps, nausea, vomiting, anemia, pancreatic damage, and a drop in high density lipoprotein cholesterol levels.

3.11.1.5 Lead

The lead concentration in the samples is less than 0.001, which is less than the WHO recommendation limit of 0.01mg/L. These findings suggested that the well fluids are not suitable for human consumption because lead in low concentrations, can be hazardous to the human system. It is critical to determine the influence of these contaminants to water quality.

4. Conclusion

The results of the above work showed that most of the physicochemical parameters e.g. total alkalinity, total hardness, turbidity, dissolved oxygen, biological oxygen demand, electrical conductivity, sulphate, phosphate, copper, and iron were respectively within the acceptable limits of WHO's recommended. However, pH, lead, nitrate, manganese, zinc, were mostly found to exceed the maximum permissible limit as recommended by WHO at some study sites, further analysis showed that there is an equal amount of manganese in the four sites. Sample 1 in the North collected from a hand dug well showed the highest case of heavy metals compared to the remaining sites. Dissolution of rock minerals with the ground water is a possible reason for pollution. All the above results confirmed the high pollution of the ground water sources and hence, they are not suitable for consumption without any prior treatment.

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