



Bacteriological and Physico-Chemical Analysis of Underground Water in Ede and its Environs

Bolaji A.S*, Attah O.T, Akanfe F.A

Department of Science Laboratory Technology, Federal Polytechnic, Ede, Osun Stat, Nigeria.

Abstract- Bacteriological and physicochemical analyses of underground water in Ede and its environs were carried out. This was with a view of determining the bacterial contamination and effect of some of the chemicals identified from the bodies of underground water in this community. The water samples were collected from Ede North, Ede South and Egbedore local government areas in Ede, Osun State, Nigeria. The bacterial species isolated from the water samples were identified using the basic bacteriological procedure while the physicochemical analyses were determined using the AOAC method. The physico-chemical parameters complied with the acceptable standard with few exceptions. None of the samples complied with the bacteriological standards as Total coliform count exceeded 1525 MPN/ml. Several bacterial species were isolated which included, *Enterobacter*, *Klebsiella*, *Corynebacterium* and *Enterococcus*. This study revealed the presence of these organisms as potential pathogens that could affect drinking water quality significantly, thus resulting in a great health challenge.

Keywords: *underground water, bacterial species, chemicals, analysis.*

1. Introduction

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers. This groundwater is valuable as a source of drinking water for most communities in the world, especially small ones. Groundwater is beneath the water table and it provides about 0.6 percent of the world's total water and 20 percent of the available fresh water resources (Dan *et al.*, 2003). The temperature of groundwater is quite steady because the specific heat capacity of water is high and also because the soil, rock and upper layer of water protect groundwater from heat changing with the climate (Moyo, 2013). The mineral content in the groundwater is usually constant, and could be higher than in the surface water from the same area (Bello *et al.*, 2013).

Generally, groundwater quality varies from place to place, sometimes depending on seasonal changes (Seth *et al.*, 2014; Thiyya *et al.*, 2014), the types of soils, rocks and surfaces through which it moves. Naturally occurring contaminants are present in the rocks and sediments. As groundwater flows through the sediments, metals such as iron and manganese are dissolved and may later be found in high concentrations in the water (Moyo, 2013). In addition, human activities can alter the natural composition of groundwater through the disposal or dissemination of chemicals and microbial matter on the land surface and into soils, or through injection of wastes directly into groundwater. Industrial discharges, urban activities, agriculture, and disposal of waste can also affect groundwater quality (Govindarajan and Senthilnathan, 2014). Pesticides and fertilizers applied to lawns and crops can accumulate and migrate to the water tables thus affecting both the physical, chemical and microbial quality of water.

Microbial contamination of underground water may affect drinking water quality significantly and this could contribute a major health challenge. It is on this note that bacterial contamination as well as some physicochemical parameters of underground water in Ede community is evaluated to assess its quality.

2. Materials and Methods

2.1 Sample Collection

Underground water samples were collected from Ede North, Ede South and Egbedore local government areas in Ede, Osun State, Nigeria. Samples were taken from five different locations in each local government area in sterile bottles that were appropriately labelled and transported to the laboratory in ice pack.

2.2 Physico-Chemical Analysis

The physico-chemical tests carried out on the samples included appearance, colour, pH, temperature, dissolved oxygen, total alkalinity, total hardness, calcium hardness, calcium ions, magnesium ions, chloride ions, iron and silica content using Association of Official Analytical Chemists method (AOAC,2005).

2.3 Bacteriological Analysis

Bacteriological characteristics of the isolates recovered from the samples were determined using the methods described by Bezuidenhout *et al.*, (2002). The Most Probable Number-multiple tube technique was used in enumerating the number of coliforms in the samples. Nutrient agar (NA) was used to determine the total heterotrophic count while other conventional media such as Mannitol Salt Agar (MSA) and Eosin Methylene Blue (EMB) agar were also used for identification. All plates were incubated at 37°C for 24-48 h. Presumptive colonies were confirmed by Gram staining and biochemical characterization of the isolates was carried out for further identification (Cowan and Steel, 1985; Osuinde and Eneuzie, 1999).

3. Results

Tables 1, 2 and 3 revealed the physicochemical analysis of water samples from different locations. The parameters analyzed included Appearance, Colour, pH, Temperature, Dissolved oxygen, Total alkalinity, Total hardness, Calcium hardness, Calcium ions, Magnesium hardness, Magnesium ions, Chloride ions, Iron, Silica, Nitrate ions, Nitrite nitrogen, Total solids, Total filterable solid, Total non-filterable, Chlorine demand (BOD), Flocculation (ppm), Carbonate ion and Bicarbonate ion. Table 4 compared the physicochemical parameters of the water samples from different locations.

All water samples from Ede South (ES) and Egbedore (EG) Local Government Areas (LGAs) appeared clear with three out of the five water samples from Ede North (EN). Samples from EN and EG have the highest colour of 20HU exceeding the acceptable values of WHO and EPA while ES had 15HU. The pH of the water samples ranged from 6.6 to 6.96 which were still within the acceptable standard. The temperature values ranged from 26.52 – 26.76°C, Dissolved oxygen was between 3.46 – 4.24 mg/l, Total alkalinity 47.2 – 80 mg/l, Total hardness ranged from 118.4 -157.6 mg/l while Calcium hardness was between 80 – 105.2 mg/l. Samples from EN had highest values for Calcium ions, Chloride ions, Silica, Nitrate ions, Nitrite nitrogen and Carbonate ions while samples from ES had the least values with the exception in Carbonate ion where the least was from EG. Samples from EG had the highest values for Iron, Total solids, Total filterable solid, Total non-filterable, Chlorine demand and Bicarbonate ions with least values in samples from EN with exceptions in Total filterable solids, Chlorine demand and Bicarbonate ions where the least values were from samples from ES. Samples from ES had highest values in Magnesium hardness and Magnesium ions with the least values in samples from EG.

The bacteriological analysis of the water samples is as revealed in Table 5. The total heterotrophic count ranged from 5.67×10^5 to 6.47×10^5 with samples from EG having the highest count. The most probable number (MPN) for presumptive total coliform count of the water samples ranged from 1525 to 1,800 MPN per 100ml with samples from EN having the lowest total coliform count of 1,525 MPN per 100ml. The bacteria isolated from all the water samples included *Enterobacter cloacae*, *Klebsiella pneumoniae*, *Aeromonas veronii*, *Bacillus polymyxa*, *Rhodococcus erythropolis*, *Micrococcus varians*, *Streptococcus* spp, *Morganella morganii*, *Staphylococcus aureus*, *Neisseria lactamica*, *Enterococcus mundii*, *Mycobacterium* spp and species of *Lactobacillus* and *Corynebacterium* (Table 6).

Table 1: Physicochemical Analysis of Water Samples from Ede South LGA

S/N	Parameters	Locations					WHO standard	EPA standard
		ES1	ES2	ES3	ES4	ES5		
1.	Appearance	Clear	Clear	Clear	Clear	Clear	-	-
2.	Colour (H.U)	15	15	15	15	15	6	15
3.	pH at laboratory	7.6	7.2	6.8	6.4	6.8	6.5	6.5-8.5
4.	Temp.(^o C) at laboratory	26.8	26.5	26.9	26.8	26.4	-	-
5.	Dissolved oxygen (mg/L)	5.02	4.08	3.42	4.10	4.60	-	-
6.	Total alkalinity (mg/L)	108.00	56.00	48.00	56.00	80.00	-	-
7.	Total Hardness (mg/L)	134.00	192.00	66.00	142.00	160.00	500	500
8.	Calcium Hardness (mg/L)	114.00	94.00	50.00	56.00	86.00	75	65
9.	Calcium ions (mg/L)	45.60	37.6	20.00	22.4	34.4	-	-
10.	Magnesium Hardness (mg/L)	20.00	98.00	16.00	86.00	74.00	50	50
11.	Magnesium ions (mg/L)	5.00	24.50	4.00	21.50	18.00	-	-
12.	Chloride ions (mg/L)	9.50	64.50	13.00	32.00	57.00	200	250
13.	Iron (mg/L)	0.060	0.080	0.160	0.072	0.044	0.3	0.3
14.	Silica (mg/L)	1.800	0.065	1.080	2.250	1.700	-	-
15.	Nitrate ions (NO ₃)	0.830	1.000	0.050	0.035	0.066	-	-
16.	Nitrite nitrogen (NO ₂) (mg/L)	0.028	0.227	0.024	0.008	0.032	-	-
17.	Total solids	56.00	136.00	80.00	162.00	60.00	500	500
18.	Total Filterable Solid	50.00	102.00	24.00	150.00	16.00	NS	NS
19.	Total non-Filterable	6.00	34.00	56.00	12.00	44.00	500	500
20.	Biological Oxygen Demand (BOD)	0.22	0.80	0.32	0.40	0.60	5	-
21.	Flocculation (PPM)	15.00	15.00	15.00	15.00	15.00	-	-
22.	Carbonate CO ₂ ⁻	108.00	56.00	48.00	56.00	80.00	-	-
23.	Bicarbonate, HCO ₃ ⁻ (mg/L)	122.00	36.00	85.40	61.00	24.40	-	-

ES= Ede South; NS= No Standard

Table 2: Physicochemical Analysis of Water Samples from Ede North LGA

S/ N	Parameters	Locations					WHO Standard	EPA Standard
		EN1	EN2	EN3	EN4	EN5		
1	Appearance	Not clear	Clear	Clear	Not clear	Clear	-	-
2	Colour (H.U)	25.00	15.00	20.00	25.00	15.00	6	15
3	pH at laboratory	7.4	6.8	6.6	6.9	7.0	6.5	6.5-8.5
4	Temp.(⁰ C) at laboratory	26.4	26.8	26.2	26.4	26.8	-	-
5	Dissolved oxygen (mg/L)	3.60	4.02	1.84	3.82	4.00	-	-
6	Total alkalinity (mg/L)	48.00	48.00	76.00	102.00	126.00	-	-
7	Total Hardness (mg/L)	130.00	134.00	156.00	176.00	192.00	500	500
8	Calcium Hardness(mg/L)	78.00	86.00	106.00	114.00	142.00	75	65
9	Calcium ions (mg/L)	31.20	34.40	42.40	45.6	56.8	-	-
10	Magnesium Hardness (mg/L)	52.00	48.00	50.00	64.00	50.00	50	50
11	Magnesium ions (mg/L)	13.00	12.00	12.50	16.00	12.50	-	-
12	Chloride ions (mg/L)	57.5	54.50	61.50	77.50	87.00	200	250
13	Iron (mg/L)	0.100	0.088	0.040	0.080	0.088	0.3	0.3
14	Silica (mg/L)	2.160	2.700	0.700	3.600	1.800	-	-
15	Nitrate ions (NO ₃ ⁻)	0.040	2.900	0.050	0.066	1.500	-	-
16	Nitrite nitrogen (NO ₂ ⁻) (mg/L)	0.009	0.903	0.030	0.032	0.337	-	-
17	Total solids	108.00	86.00	96.00	40.00	150.00	500	500
18	Total Filterable Solid	78.00	58.00	68.00	36.00	104.00	NS	NS
19	Total Non-Filterable	30.00	28.00	28.00	4.00	48.00	500	500
20	Biological Oxygen Demand (BOD)	0.20	0.30	0.80	1.20	0.2	5	-
21	Flocculation (PPM)	25.00	15.00	20.00	25.00	15.00	-	-
22	Carbonate CO ₂ ⁻	48.00	48.00	76.00	102.00	126.00	-	-
23	Bicarbonate, HCO ₃ ⁻ (mg/L)	73.20	48.00	36.60	61.00	192.00	-	-

EN= Ede North; NS=No Standard

Table 3: Physicochemical Analysis of Water Samples from Egbedore LGA

S/N	Parameters	Locations					WHO Standard	EPA Standard
		EG1	EG2	EG3	EG4	EG5		
1	Appearance	Clear	Clear	Clear	Clear	Clear	-	-
2	Colour (H.U)	20.00	20.00	25.00	20.00	15.00	6	15
3	pH at laboratory	6.4	6.8	7.2	6.2	6.4	6.5	6.5-8.5
4	Temp.(°C) at laboratory	26.80	26.80	26.4	27.10	26.70	-	-
5	Dissolved oxygen (mg/L)	4.50	3.80	4.60	2.90	3.20	-	-
6	Total alkalinity (mg/L)	54.00	58.00	34.00	30.00	60.00	-	-
7	Total Hardness (mg/L)	98.00	134.00	100.00	90.00	170.00	500	500
8	Calcium Hardness(mg/L)	64.00	82.00	90.00	52.00	116.00	75	65
9	Calcium ions (mg/L)	25.60	32.80	36.00	20.80	46.40	-	-
10	Magnesium Hardness (mg/L)	34.00	52.00	10.00	48.00	54.00	50	50
11	Magnesium ions (mg/L)	8.50	13.00	2.5	12.00	13.50	-	-
12	Chloride ions (mg/L)	38.00	58.00	36.00	29.00	80.00	200	250
13	Iron (mg/L)	0.07	0.120	0.800	0.048	0.160	0.3	0.3
14	Silica (mg/L)	1.800	3.600	1.260	0.900	0.834	-	-
15	Nitrate ions (NO ₃)	0.045	1.000	1.500	0.035	0.067	-	-
16	Nitrite nitrogen (NO ₂) (mg/L)	0.010	0.226	0.337	0.008	0.038	-	-
17	Total solids	230.0 0	182.00	206.00	114.00	166.00	500	500
18	Total Filterable Solid	210.0 0	142.00	176.00	84.00	126.00	NS	NS
19	Total Non-Filterable	20.00	40.00	30.00	30.00	40.00	500	500
20	Biological Oxygen Demand (BOD)	0.80	1.20	0.60	0.40	1.50	5	-
21	Flocculation (PPM)	20.00	20.00	25.00	20.00	15.00	-	-
22	Carbonate CO ₂ ⁻	54.00	58.00	34.00	30.00	60.00	-	-
23	Bicarbonate, HCO ₃ ⁻ (mg/L)	183.0 0	122.00	36.60	107.5	73.4	-	-

EG= Egbedore; NS=No Standard

Table 4: Physicochemical Analysis of Water Samples from Different sources compared

S/N	Parameters	ES	EN	EG	WHO Standard	EPA Standard
1	Appearance	All Clear	Clear	All Clear	-	-
2	Colour (H.U)	15.00	20.00	20.00	6	15
3	pH at laboratory	6.96	6.94	6.6	6.5	6.5-8.5
4	Temp.(°C) at laboratory	26.68	26.52	26.76	-	-
5	Dissolved oxygen (mg/L)	4.24	3.46	3.80	-	-
6	Total alkalinity (mg/L)	69.60	80.00	47.20	-	-
7	Total Hardness (mg/L)	138.8	157.6	118.4	500	500
8	Calcium Hardness(mg/L)	80.0	105.2	80.8	75	65
9	Calcium ions (mg/L)	32.00	42.08	32.32	-	-
10	Magnesium Hardness (mg/L)	58.8	52.80	39.6	50	50
11	Magnesium ions (mg/L)	14.6	13.20	9.9	-	-
12	Chloride ions (mg/L)	35.20	67.60	48.20	200	250
13	Iron (mg/L)	0.083	0.079	0.239	0.3	0.3
14	Silica (mg/L)	1.379	2.192	1.679	-	-
15	Nitrate ions (NO ₃)	0.396	0.911	0.529	-	-
16	Nitrite nitrogen (NO ₂) (mg/L)	0.064	0.262	0.124	-	-
17	Total solids	98.8	96	179.6	500	500
18	Total Filterable Solid	68.4	68.8	147.6	NS	NS
19	Total Non-Filterable	30.4	27.6	32.0	500	500
20	Biological Oxygen Demand(BOD)	0.47	0.54	0.90	5	-
21	Flocculation (PPM)	15.00	20.00	20.00	-	-
22	Carbonate CO ₂ ⁻	69.6	80.0	47.2	-	-
23	Bicarbonate, HCO ₃ ⁻ (mg/L)	65.76	82.16	104.5	-	-

Table 5: Bacteriological Analysis of Water

Sample Code	Total Heterotrophic Count	Total Coliform Count
ES	5.67x10 ⁵	1800
EN	6.26x10 ⁵	1525
EG	6.47x10 ⁵	1800
WHO Standard	1.0x10 ²	Zero per 100ml
EPA Standard	1.0x10 ²	Zero

Table 6: Cultural and Biochemical Characterization of the Bacteria Isolates

Isolate code	Cell shape	Gram reaction	Catalase	Urease	SIM	Citrate	M R	Vogues proskauer	Glucose	Mannitol	Sorbitol	lactose	Possible organism
EDA 2	Rod	-	+	-	---+	+	-	+	AG	AG	AG	AG	<i>Enterobacter cloacae</i>
EDB 2	Rod	-	+	-	---	-	-	+	AG	AG	AG	AG	<i>Klebsiella pneumoniae</i>
EDD 2	Rod	-	+	-	---+	+	-	+	AG	AG	A	A	<i>Aeromonas veronii</i>
EDE 2	Rod	+	+	-	---+	-	-	+	AG	AG	A	AG	<i>Corynebacterium avidum</i>
EDF 2	Rod	+	+	-	---	+	-	+	AG	AG	AG	AG	<i>Bacillus polymyxa</i>
EDG 2	Rod	+	+	-	---	+	-	+	AG	AG	AG	AG	<i>Rhodococcus erythropolis</i>
EDI2	Rod	+	+	-	---+	-	-	+	AG	AG	AG	NC	<i>Micrococcus varians</i>
EDJ 2	Rod	+	-	-	-+	+	-	+	AG	AG	AG	A	<i>Streptococcus mitis</i>
EDK 2	Rod	-	-	-	+++	+	-	+	A	AG	AG	A	<i>Morganella morganii</i>
EDL 2	Cocci	+	+	-	-+	+	-	+	A	A	AG	AG	<i>Staphylococcus aureus</i>
EDM2	Cocci	-	+	-	-+	+	-	+	AG	AG	A	AG	<i>Neisseria lactamica</i>
EDN 2	Rod	+	-	-	++	+	-	+	AG	AG	NC	AG	<i>Lactobacillus buchneri</i>
EDO 2	Cocci	+	-	-	-+	+	-	+	AG	AG	AG	AG	<i>Enterococcus mundtii</i>
EDP 2	Rod	+	+	-	---+	+	-	+	AG	NC	NC	NC	<i>Corynebacterium renale</i>
EDQ 2	Rod	+	+	-	---+	+	-	+	AG	AG	AG	AG	<i>Corynebacterium sp</i>
EDR 2	Rod	+	-	-	-+	+	-	+	A	NC	NC	AG	<i>Lactobacillus leichmanii</i>
EDS 2	Cocci	+	-	-	+++	+	-	+	A	A	A	AG	<i>Mycobacterium megmatitis</i>
EDT 2	Rod	-	+	-	+++	+	-	+	AG	AG	AG	AG	<i>Providential stuartii</i>

KEY:

A	Acid produced	G	Gas produced
AG	Acid and gas produced	NC	No change
+	Growth	-	No growth

4. Discussion

The study determined the bacteriological and physico chemical analysis of underground water in Ede and its environs with the view of assessing the quality. The study was aimed at determining the total heterotrophic counts, total coliform counts and number of bacterial species that contaminated the body of water which may affect drinking water quality significantly and could contribute major health challenges.

The total heterotrophic counts for all the water samples were generally high exceeding the acceptable standard of 1.0×10^2 cfu/ml for heterotrophic count for drinking water (EPA, 2002). This could be as a result of high organic and dissolved salts in the water samples. Water samples from EG had higher bacterial count while the samples from ES had the least count. Groundwater has been found to be contaminated with the fecal material of humans and other animals. This is a cause for concern because fecal material may contain pathogenic (disease-causing) microbes that can infect the intestinal tract of humans (Paul *et al.*, 2009). Most of the bacterial types found in soils and surface waters have also been found in

groundwater environment. Some of the physico-chemical parameters analyzed in this study were not in line with the acceptable standard of the World Health Organization (WHO) and the Environmental Protection Agency (EPA). Many groundwater quality parameters, such as pH, oxidation/reduction (redox) status, dissolved oxygen, or the presence of specific mineral constituents, may be influenced by microbial activity in the aquifer (Seth *et al.*, 2014). The temperature of water samples from the three sources was quite stable which was in line with another study conducted by Bello *et al.*, 2013. This could be as a result of high specific heat capacity of water and also because the soil, rock and upper layer water protect groundwater from heat changing with the climate.

Furthermore, the total coliform count for all samples exceeded the EPA Maximum Contamination Level (MCL) for coliform bacteria in drinking water of zero total coliform per 100ml of water (EPA, 2003). The increase in the coliform count may be as a result of fecal contamination of the water source (Bello *et al.*, 2013; Moyo, 2013). The bacterial isolates recovered from these water samples were both Gram positive and Gram negative. The Gram positive bacteria included *Staphylococcus aureus*, *Streptococcus mitis*, *Corynebacterium species* and *Micrococcus varians* while Gram negative bacteria included *Klebsiella pneumoniae*, *Enterobacter cloacea* and *Neisseria lactamica*. This was similar to the findings of Frank, 2000.

5. Conclusion

In conclusion, it is very obvious that most of the activities of bacteria in ground water occurred as a result of human activities which can alter the natural composition of underground water as well as dissemination of chemicals into the water bodies. All these must be avoided to guard against infections and diseases that could result from the consumption of contaminated water. Therefore, it is suggested that underground water in this environment should be well cited, away from the refuse dumpsite, and also follow the specifications for constructing a standard well (underground water) to avoid bacterial contamination.

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