Research Article

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Physicochemical studies of thirty commercial ground waters located in Benin City, Nigeria.

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Thirty commercial groundwater samples were selected randomly from Benin City, Nigeria. Samples of the waters were collected for a period of eight weeks. Physicochemical examination was carried on the waters by standard methods. The results revealed that the range of the physicochemical parameters were as follows: pH (4.85-6.93), turbidity (Nil), colour (Nil), alkalinity (2.00-13.00mg/1), electrical conductivity (7.15µsm`-13.00µsm`), total hardness (5.00mg/1-36.00mg/1), dissolved oxygen (8.62-12.10), chloride (38.40mg/1-71.50mg/1), suphate (1.20mg/1-3.50mg/1), phosphate (0.28mg/1-0.90mg/1) and nitrate (0.01mg/1-0.08mg/1). Additionally, most of the parameters were within the permissible concentrations recommended for domestic water. The results suggest that the commercial ground waters were fit for human consumption based on the physicochemical studies.

Key words: Ground water, pH, Benin City, sulphate, phosphate, nitrate.

Living organisms cannot exist or survive without water. Water is the most abundant compound in living organisms. Water from various sources contains dissolved gases, mineral, organic and inorganic substances. Water in its pure form is colourless, odorless, tasteless, and sparkling in nature (Obahigbon, 2008; Lehninger (1990); Egereonu (2006).

Water that exists below the soil level is referred to as groundwater. When rain falls, water infiltrates into the ground and percolates through the soil until it reaches a depth where all the pore spaces are filled with water. The water present in this saturated zone of the earth is referred as groundwater. Groundwater exist in aquifers, geological formations where significant amounts of water can be stored, transmitted or supplied to a well or a spring. Some groundwater flows to the surface to feed into lakes and streams (www.gem.msu.edu/gw/gw.html). In many parts of the world, groundwater typically discharges from aquifers to replenish rivers, lakes or wetlands. Conversely, surface water recharges groundwater sources. Consequently, land-use activities affecting groundwater quality especially through infiltration of pollutants can affect surface water quality as contaminants are carried with groundwater discharge.

The total water system surrounding the planet earth is called the hydrosphere. It includes fresh water systems, oceans, atmosphere vapour and biological waters. Hydrospheric processes are steps by which water cycle on the planet earth. It includes sublimation of ice, evaporation of liquid, transportation of moisture by air, rain snow, river, lake and ocean current (Egnereonu, 2004)

Arising from the unrestricted population increase in Benin City metropolis over the last decade, coupled with the locations of small, medium and large scales industries, independent installation of boreholes have been on the increase, in order to meet their water needs.

Additionally, domestic demand for water has also increased proportionately, as the infrastructures for public water supply are not able to meet the demand of the populace. As a result, boreholes are being sunk for commercial purposes from one street to the other. The activity is providing additional income for the operators. It was against this background that this study was stimulated. We are hoping that the physicochemical information that will be provided through this study will act as a guide to the populace in the area and that it will form part of the total parameters required for domestic water.

MATERIALS AND METHODS

Collection of samples: Thirty boreholes in good working conditions were selected randomly in residential houses of two local government areas in Benin City, Edo State (figure 1). Water samples were collected on weekly basis for eight weeks. The water sample was collected in polyethylene plastic bottles previously washed, rinsed with deionized water and corked with plastic screw caps.

Experimental

pH determination: The pH values were obtained at the site of collection, by using a pocket pH meter (Bates, 1973).

Turbidity: The turbidity of the waters was determined by the American standard method for water and waste water treatment (9).

Electrical Conductivity: The electrical conductivity was measured at the site of the water collection with a conductivity meter, Model WTWLF9.

Total Solids: The total dissolved solids were determined by evaporation (Gallenkamp vacuum air oven) and weighing method. (IITA, 1970).

Colour: The water colour was determined with a lovibond comparator in Hazen units.

Alkalinity: This was established in the water samples by the titrimetric method (Franson ed., 1975).

Calcium Hardness: This was determined by titrimetric method, EDTA (Titrant) with mirazine as indicator (Franson ed., 1975).

Phosphate: The phosphate was assayed by the Hach cooperation powder pillow method (IITA, 1970).

Nitrate: This was assayed for by the nitrate electrode method (American standard method, 1998).

Dissolved Oxygen: This was determined in-site by using YSI 51B Model of 0-12mg/1 range.

Sulphate: Turbidimetric method was adopted (Harrison and Perry, 1986).

RESULTS AND DISCUSSION:

The results for the studies are as presented in Table 1. The mean P^H values ranged between 4.85 and 6.93. In other words, the results indicated that the groundwater were on the range of acidity to neutral values. The low PH observed in some of the groundwater might be as a result of dissolved carbon dioxide arising from bacterial decomposition of organic matter etc. On the other hand, the near neutral P^H values obtained from some of the groundwater may be attributed to the equilibrium state the system attempted to attain (Chebotarey, 1955). The P^H is an "index" of the amount of hydrogen ion present in a substance and it is used to categorize the latter as acid, neutral or alkaline (basic). However, on the overall, the P^H of the various groundwater analyzed, indicated that, they were within allowable limit for domestic water (WHO, 1992, F.E.P.A. 1991).

The results on the turbidity of the groundwater were nil. These results were in agreement with the nil results also observed in the colour of the groundwater analyzed, since turbidity has direct influence on the colour of the water. In other words, if a sample of water is not cleared or coloured it shows that it contains suspended matter such as clay, silt, finely divided organic matter, plankton and other microscopic organisms (Ademoroti, 1996). The results for colour and turbidity showed that the ground waters meant the standard recommended for domestic water (WHO, 1992).

The electrical conductivity results (mean) ranged from 7.15 μscm^{-1} to 69.90 μscm^{-1}. The WHO recommended limit for electrical conductivity in drinking water is 14.00 µscm-1. Apart from sites 3,5,9,10,25 and 29, others sites had values above the recommended permissive level by WHO (1992). Electrical conductivity of portable waters is mainly due to dissolved mineral matter. Free carbon (IV) oxide and ammonia also impact conductivity, but their effect is negligible except in waters of very low salinity. The electrical conductivity of industrial wastewaters, treatment plant effluents and polluted waters is due to the presence of ionic solutes. So, the magnitude of the conductivity is useful indication of the total concentration of the ionic solute (Ademoroti, 1996).

The mean alkalinity values of the ground waters ranged between 2.00 mg/1 and 13.00mg/1. The alkalinity for drinking water is 100mg/1 (WHO, 1992). The results obtained suggest that the values were low and within the permissible level allowed for drinking water.

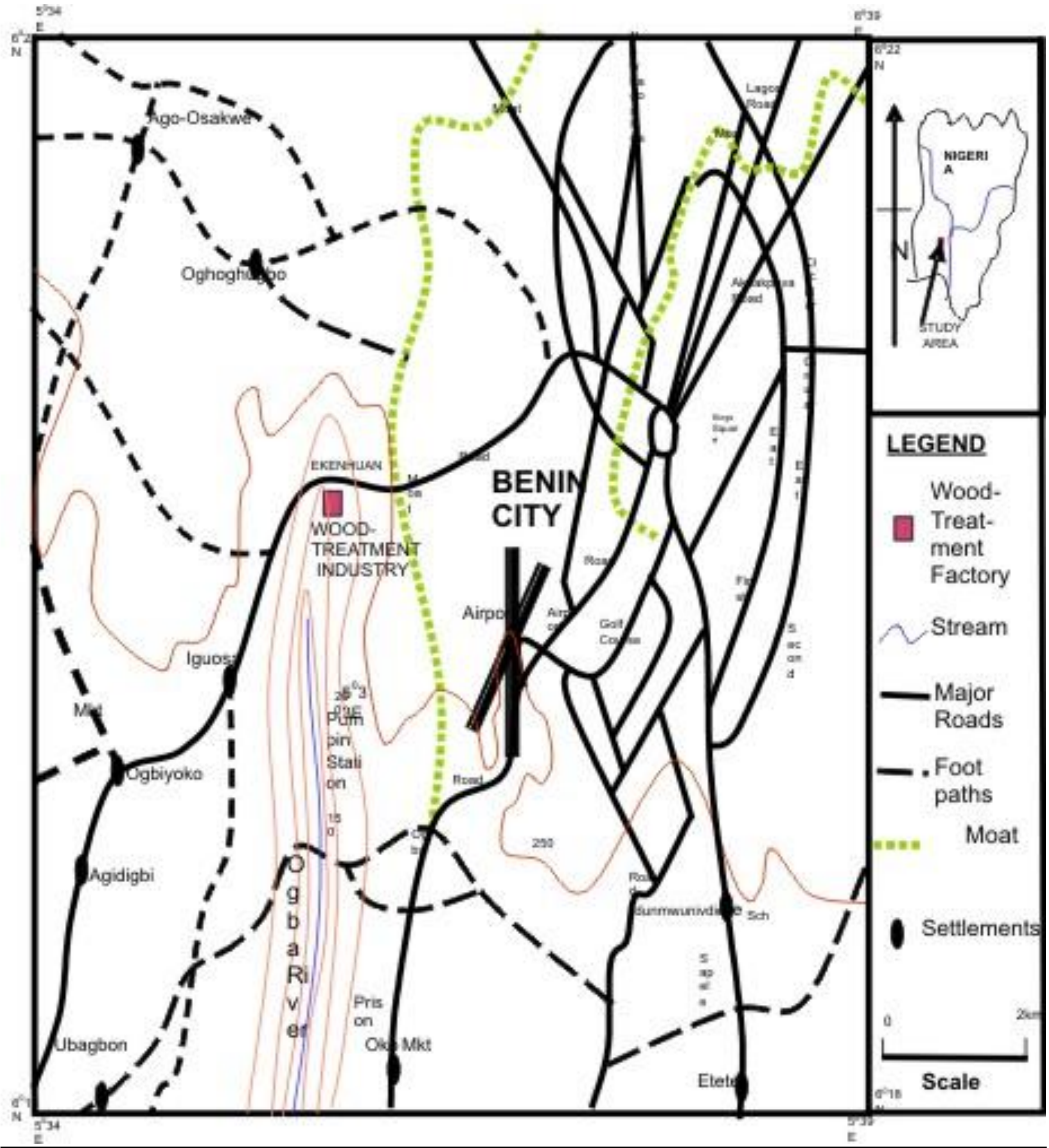

Figure 1: Sampling site of the study.

Table 1: Elemental compositions of commercial ground water samples (01-10 sites)

Sample site	1	2	3	4	5	6	7	8	9	10
pH	4.85 ± 0.03	5.70 ± 0.03	6.60 ± 0.01	5.72 ± 0.02	5.65 ± 0.04	5.42 ± 0.01	6.87 ± 0.07	6.10 ± 0.00	6.65± 0.01	5.36 ± .04
Turbidity (NTU)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
EC (Ms/cm)	69.90± 1.00	20.90 ± 0.80	7.15 ± 0.40	33.10 ± 1.00	11.31 ± 0.04	20.10 ± 0.00	15.89± 0.10	70.20± 0.80	10.30± 0.14	9.92 ± 0.28
Colour (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total Solids (mg/l)	12.00 ±1.20	10.00 ± 0.88	15.00± 1.18	10.00 ± 1.00	13.00 ± 1.10	15.00 ± 0.98	12.00± 1.00	12.00± 1.32	18.00 ± 1.00	13.00 ± 1.00
Alkalinity (mg/l)	5.00 ± 0.30	5.00 ± 0.40	8.00 ± 1.10	7.00 ± 0.10	6.00 ± 0.10	2.00 ± 0.20	10.00± 0.90	3.00 ± 0.00	5.00 ± 0.20	5.00 ± 0.20
Hardness (mg/l)	12.00 ±1.00	27.00 ± 1.20	22.00± 1.10	35.00 ± 1.00	21.00 ± 1.12	36.00 ± 1.20	15.00± 1.00	14.00 ± 1.00	31.00 ± 1.15	20.00 ± 1.00
Chloride (mg/l)	63.9± 3.00	71.20± 1.80	71.50± 2.80	71.00 ± 1.80	42.60 ± 1.40	56.20 ± 1.00	63.90± 1.20	60.10 ± 1.10	39.60 ± 1.50	69.50 ± 2.40
Sulphate (mg/l)	3.00 ± 0.00	2.54 ± 0.00	2.80 ± 0.40	2.50 ± 0.10	2.50 ± 0.00	2.30 ± 0.10	2.45 ± 0.15	3.20 ± 0.00	2.84 ± 0.15	2.60 ± 0.20
Phosphate (mg/l)	0.30 ± 0.04	0.59 ± 0.02	0.60 ± 0.04	0.64 ± 0.00	0.55 ± 0.01	0.48 ± 0.02	0.40 ± 0.03	0.28 ± 0.01	0.59 ± 0.00	0.54 ± 0.06
Nitrate (mg/l)	0.20 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
DO (mg/l)	11.20± 0.10	11.22 ± 0.00	8.85 ± 0.00	10.32± 0.20	10.95 ± 0.80	10.92 ± 0.60	10.40± 0.00	9.80 ± 1.00	11.20 ± 2.00	10.28 ± 0.90

Sample site	11	12	13	14	15	16	17	18	19	20
pH	5.78 ± 0.02	6.93 ± 0.04	6.87 ± 0.03	5.98 ± 0.02	6.29 ± 0.03	6.89 ± 0.00	6.15 ± 0.06	6.90 ± 0.05	6.43 ± 0.01	6.52 ± 0.02
Turbidity (NTU)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
EC (Ms/cm)	22.00 ± 0.20	20.00 ± 0.00	23.00 ± 0.50	24.20 ±0 .20	36.40 ±0 .30	34.00 ± .50	28.80 ±0 .30	18.00 ±0 .20	21.00 ±0 .40	19.00 ±0 .40
Colour (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total Solids (mg/l)	26.00 ± 0.80	18.80 ± 0.64	8.80 ± 0.38	20.00 ± .03	21.00 ± 0.80	15.60 ± 0.54	13.80 ± 0.20	12.60 ± 0.62	14.10 ± 0.00	12.80 ± 0.50
Alkalinity (mg/l)	2.00 ± 0.40	12.00 ± 1.00	10.00 ± 0.50	4.00 ± 0.10	5.00 ± 0.30	12.00 ±0.40	8.00 ± 0.70	13.00 ±0.40	8.00 ± 0.30	8.00 ± 0.40
Hardness (mg/l)	20.00 ± 1.20	10.00 ± 0.70	6.00 ± 0.40	19.00 ± 1.00	5.00 ± 0.42	16.00 ± 0.60	16.00 ± 0.00	10.00 ± 0.60	12.40 ± 0.50	12.00 ± 0.00
Chloride (mg/l)	38.40 ± 1.00	42.50 ± 1.60	46.70 ± 1.70	60.20 ± 0.80	48.20± 1.40	41.90 ± 1.30	50.10 ± 1.40	53.20 ± 1.30	49.10 ± 1.30	38.50 ± 1.00
Sulphate (mg/l)	2.04 ± 0.20	1.80 ± 0.20	3.50 ± 0.30	2.50 ± 0.00	1.30 ± 0.10	1.45 ± 0.20	1.20 ± 0.30	2.30 ± 0.20	2.60 ± 0.50	3.00 ±0.60
Phosphate (mg/l)	0.50 ± 0.00	0.59 ± 0.00	0.90 ± 0.08	0.46 ± 0.00	0.65 ± 0.06	0.84 ± 0.06	0.90 ± 0.04	0.28 ± 0.00	0.90 ± 0.00	0.52 ± 0.03
Nitrate (mg/l)	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.082 ± 0.00	0.01± 0.00	0.02 ± 0.00	0.02 ± 0.00
DO (mg/l)	12.10 ± 0.20	10.32 ± 0.40	9.58 ± 0.50	10.54 ± 0.70	11.52 ± 0.70	8.62 ± 0.40	10.40 ± 0.40	8.80 ± 0.40	10.20 ± 0.00	10.28 ± 0.20

Sample Site	21	22	23	24	25	26	27	28	29	30
pH	5.88 ± 0.02	5.70 ± 0.02	6.60 ± 0.00	5.72 ± 0.03	5.65 ± 0.02	5.42 ± 0.03	5.87 ± 0.04	6.10 ±0.00	5.65 ± 0.02	5.65 ± 0.02
Turbidity (NTU)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
EC (Ms/cm)	62.00 ± 0.30	21.00 ± 0.10	20.30 ± 030	23.10 ± 0.30	11.40 ± 0.20	20.10 ± 0.20	18.50 ±0.30	17.20 ±0.20	10.30 ±0.20	19.90 ± 0.30
Colour (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total Solids (mg/l)	12.60 ± 0.40	10.80 ± 0.04	12.60 ± 0.80	12.00 ± 0.00	9.00 ± 0.40	13.00 ± 0.50	11.00 ± 0.10	10.60 ± 0.62	8.40 ± 0.20	10.20 ± 0.50
Alkalinity (mg/l)	5.00 ± 0.20	6.00 ± 0.80	10.00 ± 0.30	4.00 ± 0.30	4.00 ± 0.10	2.80 ± 0.20	5.00 ± 0.40	8.00 ± 0 .40	5.00 ± 0.00	3.00 ± 0.40
Hardness (mg/l)	12.00 ± 0.82	27.00 ± 0.90	22.00 ± 0.60	35.00 ± 1.00	21.00 ± 1.20	26.00 ± 0.80	15.00 ± 0.70	14.00 ± 0.50	31.00 ± 0.50	20.00 ± 0.00
Chloride (mg/l)	42.40 ± 0.80	41.20 ± 1.20	41.50 ± 0 .70	61.00 ± 0.90	42.60 ± 1.20	56.20 ± 1.00	63.90 ± 1.00	60.10 ± 1.20	39.60 ± 1.00	69.30 ± 1.20
Sulphate (mg/l)	1.30 ± 0.30	1.54 ± 0.40	2.80 ± 0.40	2.50 ± 0.30	2.50 ± 0.40	2.30 ± 0.40	2. 40 ± 0.50	3.20 ± 0.00	2.84 ± 0.60	2.60 ± 0.60
Phosphate (mg/l)	0.50 ± 0.00	0.59 ± 0.00	0.90 ± 0.08	0.46 ± 0.00	0.65 ± 0.06	0.84 ± 0.06	0.90 ± 0.04	0.28 ± 0.00	0.90 ± 0.00	0.52 ±0.03
Nitrate (mg/l)	0.2 ± 0.00	0.01± 0.00	0.01± 0.00	0.01± 0.00	0.01± 0.00	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.0	0.01 ± 0. 00	0.02 ± 0.00
DO (mg/l)	11.20 ± 0.40	11.42 ± 0.30	10.85 ± 0.40	10.00 ± 0.40	10.95 ± 0.50	10.62 ± 0.00	10.40 ± 0.40	9.00 ± 0.40	11.20 ± 0.50	10.80 ± 0.60

The alkalinity as it relates to water analysis is the sum of components (mainly, bicarbonate, carbonate and hydroxide) which tend to raise the P^H above 4.5 (Obahiagbon, 2008). In other words, alkalinity in natural water is caused by three major classes of materials viz: hydroxides (strong bases), carbonates and hydrogen carbonate (salts of weak acids but of strong bases).

The total solids (mean) detected in the various ground waters ranged between 8.00mg/1 and 28.80 mg/1. The recommended concentration in drinking water is 100mg/1(WHO, 1994). The values detected are thus within the permissive level for drinking water. The total solids (TS) in portable water are made up of dissolved solids (DS) and the suspended solids (SS).

The hardness of the ground waters ranged between 5.0mg/1 and 36.mg/1. The recommend total hardness in drinking water is 500mg/1 (WHO, 1994). The total hardness (mean) of the ground waters indicted that they were low and within the permissible concentration in drinking water. The total hardness of a particular sample of natural water represents primarily the total concentrations of calcium and magnesium ions expressed as calcium carbonate. Waters containing hardness concentrations of up to 60mg/1 are referred to as “soft”, those containing 120-180mg/1 as “hard” (Alken Murray, 1934).

The dissolved oxygen (mean) in the ground waters ranged between 8.62 mg/1 and 12.10mg/1. The value of 7.5mg/1 is recommended as permissible concentration in drinking water (WHO, 1994). The concentrations detected in the groundwater are higher than the recommended value. Besides, the results indicated that the ground waters are highly oxygenated, being by- product of photosynthetic activity of algae and water plants (George and Franklin, 1991). Additionally, the high oxygen contents of the ground waters may be attributed to poor solubility in the available waters.

The chloride concentrations (mean) of the ground waters ranged between 38.40mg/1 and 71.50mg/1, which is quite below the recommended level of 250mg/1 for drinking water (WHO, 1994). The concentration of chloride detected in the waters might be attributed to its wide distribution in nature, it subjection to rapid recycling, and to the fact that it is one of the most mobile elements in its ionic form (Mengel and Kirkby, 1979). Chloride ion originates from human activities (Obahiagbon *et al*, 2008). Additionally, chloride might originate from refuse incineration, such as PVC, which produces HCI in gas phase (Fuzzis *et al*, 1984).

The sulphate concentrations (mean) of the ground waters ranged between 1.20mg/1and3.50mg/1.The World Health Organization standard for sulphate concentration in drinking water in 25mg/1 (WHO, 1994). The values detected in the waters are below the toxicity level for sulphate in drinking water. In fresh waters, sulphate has been identified as often responsible for the hardness and also constitutes the major anion component.

The phosphate concentrations (mean) in the ground waters ranged between 0.28mg/1 and 0.90mg/1.The World Health Organization recommended 0.1mg/1 of phosphate in drinking water. The values detected in the ground waters are obviously higher than the recommended concentration. The higher concentration of phosphate detected in the ground waters may be attributed to pollution, due to transportation within the ecosystem.

The nitrate concentrations in the ground waters ranged between 0.01mg/1 and 0.08mg/1. The World Health Organization recommended 45mg/1 of nitrate as the maximum concentration permissible in drinking water. The results obtained for the ground waters are therefore low and fit for human consumption. However, values above the recommended standard concentration for drinking water are capable of causing health disorder in children known methemoglobimea, characterized by blood changes and cyanosis in which the haemoglobin apparently becomes incapable of transporting oxygen (Egereonu and Emezain, 2006).

CONCLUSION:

The physicochemical parameters studied in the commercial groundwater have revealed that most of values are below the toxicity levels recommended by the World Health Organization. There are strong indications from the results that the various borehole waters were not polluted and are therefore fit for human consumption from the physicochemical point of view. Efforts are underway to examine the microbiological and elemental aspects of the waters.

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