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Physico-Chemical Characterisation of Ground Water available in Kaduna Polytechnic Campuses, Kaduna, Nigeria.

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Abstract : *The physicochemical properties of groundwater from various locations on all four campuses of the Kaduna Polytechnic were analyzed. The samples taken from thirteen different locations revealed physico-chemical parameters within the following range: pH (7.25-7.67), Temp (20.2-20.9ºC), conductivity (090-563 µS/cm), chloride (2.33-495.6 mg/l), total hardness (0.24-3.04 mg/l), Total dissolved solids (380-3090mg/l) Total suspended solids (0-12mg/l), alkalinity (184-688 mg/l). Turbidity (0-5NTU), Dissolved oxygen (22.2-49.5mg/L), Biological oxygen demand (6.5-15.4mg/L), Calcium (0.12-0.90mg/l, Magnesium (1.28-6.08mg/l) and Nitrate (0.03-0.32 mg/l). The results revealed that most of the parameters analyzed were consistent with the WHO maximum permissible limit for drinking water which satisfies the safety limit for their use for various purposes. It was observed that chloride levels were high in three of samples all sourced from the students hostel.*

Keywords: *groundwater, Kaduna, physicochemical, polytechnic*

I. Introduction

Water, one of the most indispensable resources is the elixir of life. Providing safe and secure water to people around the world, and promoting its sustainability is one of the fundamental objectives of the Millennium Development Goals. The world has recognized the important link between the environment and human health. In recent times, there has been an increasing interest in not just the availability of water but the access to fresh water. Fresh water is essential to human health, agricultural, industry and natural ecosystems, but is now running scarce in many regions of the world [1]. Ground water is generally considered as a safe source of fresh drinking water [2]. Unfortunately, rapid urbanization and increase in man's activities have led to greater demand of quality water due to an increase in pollutants in the environment. As such, ground water has become increasingly more polluted.

It is very important to test water before using it for drinking, domestic, agricultural or industrial purpose. Groundwater plays a fundamental role in shaping the economic and social health of many urban areas [3]. Groundwater is water that exists underground [4]. In Kaduna, water supply by the water corporation is considered inadequate and hence, most people resort to groundwater. Ground water quality is normally characterized by different physico-chemical characteristics. These parameters change widely due to the type of pollution, seasonal fluctuation, ground water extraction, etc. Monitoring of water quality levels is thus important to assess the levels of pollution and also to assess the potential risk to the environment [5].

The Kaduna Polytechnic established in 1968 is the biggest higher institution in northern Nigeria after the Ahmadu Bello University (ABU) Zaria. It comprises of four campuses, housing five colleges which are College of Science and Technology (CST), College of Business and Management Studies (CBMS), College of Environmental Studies (CES), College of Engineering (COE) and College of Administrative Studies and Social Sciences (CASSS), with CST and COE combined to form the main campus. Many human and natural activities have taken place over the years which must have led to an alteration in the quality of the water available for domestic use and other related activities like prayers and drinking purposes. In the polytechnic campuses, ground water is used largely for domestic purposes by students and staff residing on campus. In the present work, attempts have been made to evaluate the quality of groundwater resources in all campuses of the Polytechnic which has not been reported so far. This work will be an attempt to examine the different parameters of ground water and will compare these with the standards of potable water. This study could serve as a guideline for further and thorough analyses of all forms of water available on campus.

II. Experimental Methods

2.1. Study Sites

All water bodies chosen for this study are located within the four campuses of the Kaduna Polytechnic. On every campus, ground water is the major water source which is usually pumped to the surface using public electricity or diesel generators. The Geographic location of the study sites on the various campuses are shown in Table. 1

Table 1: Sample codes and Geographical locations

SAMPLE CODE	Campus	Location	Source	LATITUDE "N"	LONGITUDE "E"
WAI	CASS	Dept. of L.G. Studies	Borehole	10^O 26.271	7^O 27.517
WE1	CES	School Mosque	Borehole	10^O 29.385	7^O 25.695
WE2	CES	Bursar's Office	Borehole	10^O 29.385	7^O 25.608
WE3	CES	Sch. of Env. Design	Borehole	10^O 29.385	7^O 25.610
WS1	CST	Enactus Secretariat	Well	10^O 31.235	7^O 25.253
WS2	CST	Applied Science Dept.	Borehole	10^O 31.183	7^O 24.535
WS3	CST	Food Technology	Borehole	10^O 31.178	7^O 24.415
WS4	CST	Boys Hostel	Borehole	10^O 31.193	7^O 24.455
WS5	CST	Chemical Engineering	Borehole	10^O 31.361	7^O 24.412
WB1	CBMS	CBMS Clinic	Borehole	10^O 31.288	7^O 26.768
WB2	CBMS	Coop. Eco and Mgt	Borehole	10^O 31.179	7^O 26.403
WB3	CBMS	Boys Hostel 1	Well	10^O 31.061	7^O 26.514
WB4	CBMS	Boys Hostel 2	Borehole	10^O 31.210	7^O 26.606

2.2. Sampling

The samples were collected in polyethylene bottles (2 L capacity) which had been thoroughly washed and filled with distilled water and then taken to the sampling site. The bottles were emptied and rinsed several times with the water to be collected. The sample bottles were partially filled with the collected water and vigorously shaken. The sample bottles were covered immediately after collection and the temperature taken.

2.3. Physico-Chemical Characteristics

Physico-chemical tests were conducted on the collected samples in the laboratory of the Kaduna Environmental Protection Agency. Analytical grade reagents and chemicals were used to prepare reagents and calibration standards. Color and odor were measured by sensory tests or general observations, temperatures were recorded upon collection. The following parameters were analyzed: pH, temperature, Total alkalinity, Total hardness, Calcium, Magnesium, Dissolved oxygen, Biological oxygen demand, Turbidity, Electrical conductivity, Total dissolved solids, Total suspended solids, calcium, magnesium, nitrates and chloride as per standard procedures recommended by APHA method [6]

III. Results and Discussion

Important physicochemical parameters of samples analyzed are presented in Tables 1 and 2 below. The behavior of major ions (Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-) and physico-chemical parameters such as color, odor, pH, temperature, electrical conductivity (EC), dissolved oxygen, total dissolved solids(TDS),total suspended solids(TSS),total hardness (TH), alkalinity and Biological oxygen demand(BOD_5) and the suitability of groundwater in the study area are discussed below.

3.1 Color and Odor:

All samples were observed to be colorless and free of odor. This indicates that samples are most likely free of leachates from agricultural wastes, domestic sewage and industrial effluents through surface water to the shallow groundwater.

Table: 2: Physical parameters of the samples of ground water in Kaduna Polytechnic campuses.

Sample code	Temp (ºC)	EC µS/cm	DO mg/l	TDS mg/l	TSS mg/l	Turbidity NTU	Total Hardness
WS1	20.4	272	42.9	1680	0	1	1.80
WS2	20.0	262	31.0	1500	2	0	0.72
WS3	20.2	182	29.3	1020	0	1	1.28
WS4	20.6	563	40.2	3090	0	3	3.04
WS5	20.1	114	42.3	0580	0	5	0.96
WB1	20.5	136	26.6	0970	12	0	0.32

WB2	20.3	135	24.8	0950	2	0	0.82
WB3	20.3	286	19.3	1735	0	2	1.08
WB4	20.3	302	38.9	1860	1	0	1.50
WE1	20.3	106	22.2	0490	0	3	0.76
WE2	20.9	106	22.2	0490	0	0	0.64
WE3	20.5	124	23.3	0700	4	0	0.24
WA1	20.2	090	49.5	0380	0	0	1.70
RANGE	20.2-20.9	090-563	22.2-49.5	380-3090	0-12	0-5	0.24-3.04
AVG	20.6	326.5	31.7	1735	0.7	0.8	1.64
WHO limits	**	**	7.5	1000	**	10	

** --- not defined

3.2 Temperature

The measured temperature values of the ground water samples were between 20.2-20.9 ^{O}C. Cool waters are generally more potable for drinking purposes, because high water temperature enhances the growth of micro-organisms and hence, taste, odor, color, and corrosion problem may increase [7].The slight variation in temperatures in the water samples show some uniformity of the groundwater temperature in the study area.

3.3 Total dissolved solids (TDS)

Total dissolved solids (TDS) are the term used to describe the inorganic salts and small amounts of organic matter present in solution in water [8]. TDS values obtained for the water samples studied varied between a minimum of 380 mg/L and a maximum of 3090 mg/L According to WHO specification TDS up to 500 mg/L is the highest desirable and up to 1,500 mg/L is maximum permissible [9]. WS1, WS4, WB3 and WB4 samples had TDS levels of 1680, 3080, 1735 and 1860 mg/L respectively which were higher than the maximum permissible levels.WS2 was collected from an open well at the Enactus Secretariat at the CST campus, WS4 was from Boy's Hostel (CST) while WB3 and WB4 were collected from the Boy's hostel at the CBMS campus. These high TDS concentrations in these samples could be due to leaching of salts from soil or domestic sewage generated from the hostel. According to the Davis and De Wiest [10] classification of groundwater based on TDS, 82 % of the total groundwater samples are desirable for drinking (TDS < 500 mg/l), 14 % permissible for drinking (500–1,000 mg/l) and 4 % is suitable for irrigation purposes. High values of TDS in ground water are generally not harmful to human beings but high concentration of these may affect persons who are suffering from kidney and heart diseases [11, 12].

3.4 TSS and turbidity.

Total suspended solids (TSS) include all particles suspended in water which will not pass through a filter. The total suspended solids (TSS) values obtained are generally below WHO permissible limit 30mg/L, [13] ranging from 0 to 12.0mg/L.

Turbidity is one of the important physical parameters for water quality, defining the presence of suspended solids in water and causes the muddy or turbid appearance of water body [14]. Turbidity values ranged from 0 to 5 NTU. All samples were within the WHO prescribed limits with maximum permissible level of 10NTU [9].

3.5 Dissolved oxygen (DO)

Maximum dissolved oxygen level was found in WA1(49.5mg/L) and minimum values in WE1 and WE2 (22.2mg/L).The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chemical or biological processes taking place in the distribution system. Depletion of dissolved oxygen in water can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide. It could also cause an increase in the concentration of ferrous iron in solution, with the attendant discoloration at the tap when the water is aerated. No health-based guideline value is recommended [15].

Table 3: Chemical constituents of the samples of ground water in Kaduna Polytechnic campuses.

Sample code	**Alkalinity (mg/)l**	**BOD (mg/l)**	**pH**	**Ca (mg/l)**	**Mg (mg/l)**	**Cl (mg/l)**	**NO_3 (mg/l)**
WS1	312	15.4	7.53	0.90	3.60	79.94	0.07
WS2	320	12.3	7.67	0.36	1.44	136.8	0.03
WS3	184	7.7	7.48	0.64	2.56	190.1	0.19
WS4	384	13.2	7.60	1.52	6.08	268.2	0.08
WS5	336	12.4	7.60	0.48	1.92	23.1	0.17

WB1	536	8.1	7.62	0.16	0.65	39.25	0.10
WB2	392	7.5	7.63	0.41	0.64	142.1	0.32
WB3	264	7.3	7.25	0.54	2.16	257.6	0.28
WB4	440	9.51	7.25	0.36	0.44	495.6	0.17
WE1	688	7.7	7.58	0.38	1.52	2.33	0.21
WE2	360	6.5	7.60	0.32	1.28	103.03	0.28
WE3	400	8.0	7.50	0.12	0.48	195.40	0.24
WA1	280	14.3	7.63	0.84	3.40	39.26	0.16
RANGE	184-688	6.5-15.4	7.25-7.67	0.12-0.90	1.28-6.08	2.33-495.6	0.03-0.32
AVG	376.6	8.8	7.53	0.54	2.01	151.7	0.17
WHO limits	600	**	6.5-8.5	75	50	200	50

3.6 pH

pH is a measure of the concentration of hydrogen ions and hydroxyl ions in water. The limit of pH value for drinking water is specified as 6.5–8.5 [9]. The pH value of the groundwater samples in the study area varies from 7.25 to 7.62 clearly showing that the groundwater in the study area fell within recommended limits for drinking water.

3.7 Electrical conductivity (EC)

Electrical conductivity (EC) of water is a direct function of its total dissolved salts [16]. It is an index to represent the total concentration of soluble salts in water [17]. The Electrical conductivity (EC) for all the sampling sites varied between 090-563 µS/cm. The highest EC value was recorded at sampling point WS4 (CST) whereas WA1 (CASS) registered the lowest value. The measured EC values indicate that all the examined groundwater had values which were within the WHO maximum allowable EC level of between 50-1500µS/cm for drinking water

3.8 Calcium and magnesium

Calcium and magnesium are parameters directly related to hardness. Ca^{2+} ranged between 0.12-0.90mg/L in all samples while Mg^{2+} ranged between 1.28-6.08 mg/L. These levels were within the [15] permissible levels which are 75mg/L for Ca^{2+} and 50 mg/L for Mg^{2+}.

3.9 Chloride and nitrate

No health-based guideline value is proposed for chloride in drinking-water [15]. Chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water. Taste thresholds for the chloride anion depend on the associated cation [15].The desirable limits for chloride is specified as 200mg/L [18]. Cl^- in this study ranged between 2.33-495.6mg/L. The chloride levels in three samples WS4 (Boys hostel CST), WB3 and WB4 (Boys hostel CBMS) were above the WHO limits. The values recorded were 268.2mg/L, 257.6 and 495.6 mg/L respectively. These high chloride levels all recorded in the hostels must be due to human activities, sewage and domestic water seeping into the earth for several years. Nitrate levels ranged between and 0.03-0.32mg/L with an average value of 0.17mg/L. The WHO [19] allows maximum permissible limit of nitrate of 5 mg/l in drinking water. Nitrate commonly occurs naturally in groundwater, but high concentration might be associated with animal and human waste, open septic or sewage systems and fertilization of farms [20]. These results indicate that the quantity of nitrate in the study sites is acceptable in all the campuses.

3.10 Total hardness

Water hardness is the measure of the capacity of water to react with soap. The highest total amount (3.04 mg/L) of ground water hardness was recorded at WS1 whereas the lowest value of 0.24 mg/L was found at WE3. Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard [21]. Using the above water hardness classification, all the ground water monitored can be classified as soft thus being suitable for domestic purposes.

3.11 Biochemical oxygen demand

Biochemical oxygen demand (BOD), also called biological oxygen demand) is the amount of dissolved oxygen needed (i.e., demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is commonly expressed

in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water [22]. According to [23], most pristine rivers will have a 5-day carbonaceous BOD below 1 mg/L. Moderately polluted rivers may have a BOD value in the range of 2 to 8 mg/L. Rivers may be considered severely polluted when BOD values exceed 8 mg/L. BOD_5 values in the studied area varied between 6.5 -15.4mg/l .This implies that most of the water sampled are moderately polluted with organics which could be attributed to percolation of hydrocarbons from the environment, WS1 (well water from Enactus secretariat CST) had the highest level of BOD_5.

IV. Conclusion

In this study, water samples from groundwater sources from thirteen different locations on all the four campuses of the Kaduna polytechnic were taken. From these water samples, some selected physico-chemical parameters were analyzed to predict the ground water quality status of the Polytechnic campuses. Based on the results obtained, most of the physico-chemical parameters analyzed complied with the WHO drinking water guidelines. In some sites, however, some of the constituents were not within the desirable limit. It is recommended that further studies be carried out to identify the cause of this problem and water should be treated before made available for use.

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