World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(Research Article)

Physicochemical characteristics of the water in selected hotel swimming pools in Awka, Anambra State Capital, Nigeria

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World Journal of Biology Pharmacy and Health Sciences, 2025, 23(01), 013-021

Publication history: Received on 20 May 2025; revised on 30 June 2025; accepted on 03 July 2025

Article DOI: https://doi.org/10.30574/wjbphs.2025.23.1.0639

Abstract

Background: Water is vital for survival of humans and other life forms. It is required for human daily activities including drinking, cooking, washing, bathing and for agricultural, industrial, and recreational purposes. A swimming pool is a structure designed to hold water to enable swimming or other leisure activities.

Aim: This study aimed at assessing the physicochemical characteristics of selected swimming pools in Awka, Anambra State Capital, in Nigeria.

Methods: A total of 40 water samples were collected from ten swimming pools located within popular hotels and suites in Awka capital territory. The samplings were made during the weekend when the pools were usually busy. *In situ* measurements were carried out for pH and temperature. The physicochemical characteristics were assayed using standard laboratory methods.

Results: The results obtained showed that the temperature, conductivity, total dissolved solutes, turbidity, nitrate, phosphate, sulphate and heavy metals were within the specification 21 – 30 °C , ≤ 2000 µS/cm, ≤1000 ppm, ≤6 NTU, 1-5 ppm, 1-10 ppm and ≤360 ppm respectively of WHO and Environmental Protection Agency standards for recreational water. While pH, alkalinity, Ca-hardness, free chlorine were out of specification 7.1 – 7.8, 80 – 120 ppm, 200 – 300 ppm, 1 -3 ppm, 1 – 10 ppm and ≤5 ppm respectively.

Conclusion: In conclusion, the water qualities of the various swimming pools were fit for recreational usage although more effort should be applied to improve some of the physicochemical properties. Proper pool water treatment and training of operators might reduce health risks in the pools water.

Key words: Hotels; Physicochemical Characteristics; Pool Operators; Suites; Swimming Pool

1. Introduction

Water is very vital for the survival of humans and other life forms. It is required for human daily activities such as drinking, cooking, washing, bathing and for agricultural, industrial and recreational purposes [1]. A swimming pool is a structure designed to hold water to enable swimming or other leisure activities. Pools can be built into the ground (in-ground pools) or built above ground (as a freestanding construction or as part of a building or other larger structure), and are also a common feature aboard ocean-liners and cruise ships. In-ground pools are most commonly constructed

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from materials such as concrete, natural stone, metal, plastic or fiberglass, and can be of a custom size and shape or built to a standardized size, the largest of which is the Olympic-size swimming pool. It is also used for other bathing activities, such as playing, wading, water exercising, or cooling off on hot days. The quality of drinking water in most African countries is a call for concern let alone the quality of swimming pools [2]. A very few information exists about the water quality of swimming pools in Africa because most researchers concentrate on the quality of drinking water. However, the quality of swimming pool water must be as good as drinking water due to the risk of exposure to the body orifices during swimming [3][4].

Awka is the capital of Anambra State of Nigeria. In this capital city, swimming pool is one of the recreational facilities patronized by different classes of people for leisure or pleasure in most of the hotels or suites. The number of swimming pools is on the increase and information about their sanitary condition is scanty and water quality monitoring units are lacking in most of these pools [5]. More importantly, very little information exists when it comes to the quality of water for recreation and especially swimming pools in Africa as well as West Africa [3]. There is currently little or no data about the physiochemical standards of these swimming pools. Some managers of these hotels and suites tend to apply chemicals used for sanitizing the pools inappropriately due to scarcity or inexperience. This may lead to under-usage or overload of these chemicals and it could compromise the quality of the swimming pools water [6]. For instance, under application of chlorine or chlorine compounds will help microorganisms to thrive in the water and over application may lead to toxic effects on swimmers. These expose swimmers to myriads of infections knowing that the average amount of water swallowed by adults and non-adults during a normal swimming session is approximately 16 and 37 ml, respectively [2]. The volume may be more in those who do not know or are learning how to swim.

The need to investigate the health and hygiene of swimming pools for physicochemical parameters in Awka metropolis and Nigeria at large to ascertain the extent of the contamination levels in swimming pools as well as compliance of swimming pools to international standard is important. In this study therefore, effort was made to determine the physiochemical water quality of ten swimming pools located in public hotels and suites in Awka, the capital of Anambra State, Nigeria and to compare the parameters to the World Health Organization Standards for Recreational Water.

There are five main chemical parameters which are important in the operation of public pools. They are pH, total alkalinity, hardness, disinfectants and stabilizer (cyanuric acid). pH is defined as a measure of the acidity and basicity of pool water. Recommended range in public pools: 7.2 - 7.8. Low pH causes corrosion, staining, and chlorine loss and eye & skin irritation; while high pH causes scaling, cloudy pool, chlorine inefficiency and eye & skin irritation. Total alkalinity (TA) is the measurement of the ability of pool water to resist changes in pH. Total alkalinity is the governor of pH. Recommended range in public pools is 80 - 120 ppm (ppm - parts per million). Low TA causes pH bounce, corrosion and staining while high TA results in pH drifts to 8.4, scaling and cloudy water. Hardness is the amount of calcium in solution in pool water. Recommended range in public pools is 200 - 300 ppm. Low hardness leads to water that will etch plaster, pit metal or roughen pool surfaces and staining where as high hardness causes scaling and cloudy pool. Furthermore, a disinfectant is an agent which reduces the level of micro-organisms present in significant numbers (usually 99.9% or more) to safe levels as established by Federal or Provincial Health Authorities. Chlorine and bromine compounds are the most common disinfectants used in public pools. Chlorine is available in many forms such as chlorine gas, calcium hypochlorite, sodium hypochlorite, lithium hypochlorite, Trichloro-S-Triazinetrione and Sodium Dichloro-S-Triazinetrione. Recommended residuals for free available chlorine (FAC) in public pools are as follows: Indoor Pools: 1.5 ppm (minimum acceptable limit 0.5 ppm) and Outdoor Pools: 3.0 ppm (minimum acceptable limit 1.0 ppm)

Note: The FAC residual should not be greater than 5 ppm when bathers are in the pool water. Bromine used in public pools is available in two forms. They are: Organic bromine and Sodium bromide and potassium monopersulfate. Recommended residuals for total bromine are: 2 - 3 ppm. Ultraviolet rays of sunlight dissipate free available chlorine in outdoor pools quickly. Thus, stabilizer is used in outdoor pools to prevent chlorine from evaporating or dissipating from the pool water. The stabilizer used in outdoor pools is cyanuric acid. Chlorine residuals (free available chlorine) stabilized with cyanuric acid usually lasts three to five times longer. Recommended range for cyanuric acid in outdoor pools is 25 - 50 ppm. Physical Parameters include: Water Temperature which is recommended to be within 21 – 32 °C.

2. Materials and Methods

2.1. Materials/Reagents

Desiccators, Methyl Orange, Phenolphthalein, Eriochrome Black T, Erlenmeyer Reflux Flask, Condenser, Hot Plate, Petri dishes, Cover glasses, Potassium Chromate Indicator, Eosin Methylene Blue, 0.1 M Tetraoxosulphate (VI) acid, Silver trioxonitrate (V) solution, Total Hardness Buffer Sol (pH10), Di-Sodium EDTA Solution (1), Murexide/NaCl indicator, Ammonium Chloride, Conc. Tetraoxosulphate (VI) acid Analer grade, Ammonium Molybdate, Ammonium Vanadate, Trioxonitrate (V) acid, Analer grade, Anhydrous Sodium Sulphate, Barium Chloride, Potassium Nitrate, KNO_3, Chloroform (ACS grade), Brucine, Magnesium Sulphate, Alkali-iodide-azide solution, Phosphate buffer, Calcium chloride, Iron (III) Chloride, Glucose azide broth, $CdSO_4\text{-}8H_2O$, $K_2Cr_2O_7$, $CuSO_45H_2O$, Ferrous Ammonium Sulphate, $KMnO_4$, Zinc Pellets, Ni $(NH_4)_2$ $(SO_4).6H_2O$, $(CH_3COO)_2Pb$ or $Pb(NO_3)_2$, Distilled water, Potassium Chloride (KCI), Borax ($Na_2B_4O_7$. $10H_2O$), Sodium sulphide, Glacial acetic acid, BOD Bottles

2.1.1. Equipment

Model Buck Scientific VGP 210 Spectrophotometer (AAS), Model 3305 Jenway pH meter, Model 470 Electroconductivity Meter, Model Spectronic 21D Milton Roy Turbidimeter, Model AE 2005 Mettler Analytical balance, Gallen Kamp Incubator, Model E240 Tamsun Oven, Thermometer, Mercury-in-Glass 10 – 110 °C.

2.2. Methods

Following the World Health Organization (WHO) standards for water analysis, the methods used for physical properties for conductivity was conductivity meter model 470, turbidity was turbidity meter model 21D Milton spectronic, temperature by mercury-in-glass, 10 to 100 °C thermometer. For chemical properties, pH was determined using model 3305 Jenway pH meter. For total hardness, titrimetric method was used, free chlorine and total chlorine coloumetric method was used while sulphate, phosphate and nitrates were analyzed by uv-vis spectrophotometer.Analysis of heavy metals was done using Buck Scientific VGP 210 spectrophotometer (AAS), acetylene flame and cathode lamps

2.2.1. Sample Collection

Water samples were collected from ten different swimming pools in popular hotels and suites in Awka metropolis. Samples were collected directly into clean and air-dried plastic containers that had not been used at three different points and mixed. Samples were collected during the day when pools were in use. On site, the plastic containers were rinsed properly with the water samples from source before filling them up and capping them tightly. All samples were labeled and stored carefully.

2.2.2. Preservation of Samples

Samples preservation was done according to prescribed procedures [7]. Samples for physicochemical parameters were put into 1.5 L plastic container while samples for metal analyses were taken in 1 L plastic container and preserved or acidified to pH < 2 (HNO_3). Samples were kept in a cooler at about 4 °C prior to transportation to the laboratory where they were further preserved before analysis within 24 hours of sampling.

2.3. Determination of Physical Parameters

2.3.1. Temperature

The temperatures of the water samples were taken on the spot immediately after the samples were collected with the mercury-in-glass thermometer and recorded accordingly.

2.3.2. pH

The pH meter (3305 Jenway Model) was used. It was calibrated with buffer pH 7. The electrode was then rinsed with distilled water. A small beaker was half filled with one of the samples and the electrode was dipped into it. The value of the pH fluctuated until it stabilized, and the reading was taken and recorded. The electrode was removed, rinsed with distilled water and cleaned before it was used for the other samples.

2.3.3. Conductivity and total dissolved solutes (TDS)

The conductivity meter was switched on by pressing the power button and allowed to stabilize for 10 minutes. The meter was calibrated by immersing the probe into 0.1 M KCl solution. The probe was rinsed and then immersed in the water samples. The conductivity of the sample was taken and recorded by pressing CND on the meter and total dissolved solute.

2.3.4. Turbidity

The turbidimeter (Spectromic 21/D Milton Roy Model) was connected to an alternating current (AC) supply and switched on. The turbidimeter gauge was then standardized. A measured amount of water sample was put in a test tube and inserted into an opening in the turbidimeter. The turbidity was observed and recorded.

2.4. Determination of Chemical Characteristics

2.4.1. Free Chlorine Determination (Using Color-wheel Test Kit)

The 10 ml of water sample was taken into a test jar. One spoonful of FC1DPD (N, N diethyl-p-phenylenediamine) was added into the jar and mixed well to dissolve. The presence of pink color indicated the presence of chlorine. The FC2 (color wheel) was used to visually match the color to a numerical free or total chlorine in part per million (ppm).

2.4.2. Alkalinity (Carbonate and Bicarbonate)

The 50 ml sample was pipetted into a conical flask, 3 drops of phenolphthalein indicator were added and the solution turned pink. This was then titrated drop-wise with 0.1 M tetraoxosulphate (VI) acid solution until the pink color disappeared. The volume of acid used was recorded (P value). Then two drops of methylorange indicator were added to the sample and the sample turned yellow. The 0.1 M tetraoxosulphate (VI) acid solution was titrated against the sample until permanent reddish or orange color appeared. The volume of acid used was recorded (N value) and the sample was retained for chloride determination [8].

$$\text{Carbonate concentration (mg/L) } CaCO_3 = V_p \times M \times 100{,}000/\text{Volume of sample (ml)}$$

Vp = Volume of acid used
M = Molarity of acid

$$\text{Bicarbonate concentration (mg/L)} = \text{N value} \times M \times 100{,}000/\text{Volume of sample (ml)}$$

N value = Volume of acid used
M = Molarity of acid

2.4.3. Total Hardness Determination

A 25 ml water sample was diluted to 50 ml with distilled water in an Erlenmeyer flask. 1 ml buffer solution (40 g of Borax in 800 ml distilled water; 10 g of NaOH and 5 g of Na_2S in 100 ml distilled water, the mixture was made to a liter with distilled water) was added followed by the addition of indicator (Eriochrome Black T) and the color of water sample was blue with a reddish tinge. The solution was then titrated with 0.01 M EDTA solution slowly from a micro-burette with continuous stirring until the last reddish tinge disappeared. The last few drops were added at 3 – 5 seconds interval, which gave a blue end point. A blank titration was carried out using distilled water (the same volume as the water sample) and identical volumes of buffer and indicator were also added. Both readings of the EDTA were recorded for the two titrations [8].

$$\text{Hardness (EDTA) mg } CaCO_3/L = A - B \times M \times 1000/\text{Vol. of sample}$$

A = Vol. of EDTA for the sample
B = Vol. of EDTA for the blank
M = mg $CaCO_3$ equivalent to 1ml EDTA titrant

2.4.4. Nitrate Determination

Standard Nitrate: NO_3^- solution in 100 ppm was prepared by serial dilution of 0.16 g of KNO_3 in distilled water. 0.5 ml chloroform was added as a preservative and made to 1000 ml mark. NO_3^- working standard. Solution (10 ppm) was prepared by pipetting 10 ml of the stock into a 100 ml flask and made to mark. From the solution 0, 1, 2, 3, 4 and 5 ml were pipetted into 50 ml flask and made to mark to give 0, 0.2, 0.4, 0.6, 0.8, and 1.0 ppm: the color developing reagent was then added. 10 ml of the titrate was pipette into a 50 ml flask, 2 ml of 2.5% brucine was added followed by 10 ml conc. H_2SO_4 rapidly. This was properly mixed and left to stand for 10 minutes. The standards were similarly treated, the samples and standards were then made to mark with water, and read spectrophotometrically at 470 nm. The readings for all the various concentrations were taken and plotted against absorbance. The absorbance was measured and the corresponding nitrate concentration as determined by extrapolation from the calibration curve.

$$NO_3 \text{ (mg/L)} = IR \times SR \times 1000/\text{Sample (ml)}$$

IR - Instrumental Reading
SR - Slope Reciprocal

2.5. Sulphate Determination

Standard solution was prepared by dissolving 0.140 g anhydrous sodium sulphate Na_2SO_4 in distilled water and serially diluted to (100 ppm). Working standard solutions were prepared by pipetting 5, 10, 15, 20, and 25 ml of the primary standard, (100 ppm sulphate solution) into series of 100 ml volumetric flasks and each was made up to mark with distilled water corresponding to 5, 10, 15, 20, and 25 ppm of sulphate respectively. Each 100 ml of solutions were poured into 250 ml Erlenmeyer flask and 5 ml conditioning reagent was added. This was then mixed with the magnetic stirrer, and while stirring, a spoonful of barium chloride crystals was added then stirred for 1 minute at constant speed. Some of the solution was poured into the absorption cell and the absorbance was read at 425 nm of the spectrophotometer. The readings for all the various concentrations were taken and plotted against absorbance. The absorbance was measured, and the corresponding sulphate concentration was determined by extrapolation from calibration curve [8].

SO4-2 (Mg/L) = Mass of SO4-2 read from curve x 1000/Vol. of Sample (ml)

2.6. Total Phosphate Determination

A 100 ml of sample was poured into a beaker, 1 ml conc. Tetraoxosulphate (VI) acid was added and then the mixture was evaporated to near dryness on a hot plate. The residue was then transferred into a 50 ml volumetric flask and rinsed with 5 ml of 5 N HNO3, 5ml of 10% ammonium molybdate solution was added followed by 5 ml of 0.25% ammonium vanadate (in 6N HCl). Distilled water was then added to dilute to the mark and left to stand for 10 minutes. The absorbance of the yellow reaction product vanadomolybdophosphate was measured at 460nm with the spectrophotometer; a blank measurement was also carried out through the same steps. A calibration curve was then prepared by using a series of standard solutions and phosphate concentration extrapolated [8].

Total Phosphate (mg/L) = Reading from curve x 1000 x D1/sample (ml)

D1 = Dilution factor

Determination of Heavy Metals (Pb, Zn, Fe, Cr, Cd) Using an Atomic Absorption Spectrophotometer (AAS)

Atomic absorption spectrophotometer's working principle is based on the sample being aspirated into the flame and atomized AAS's light beam is directed through the flame into the monochromator and into the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their characteristic absorption wavelength a source lamp composed of that element is used, making the method relatively free from spectral radiation interference. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample. Reagents include: Air - Acetylene flame, Metal free distilled water, standard metal solution of the metals to be analyzed. (Zn, Pb, Fe, Cr and Cd). The sample is thoroughly mixed by shaking and 100 ml of it is transferred into a glass beaker of 250 ml volume, to which 5 ml of conc. nitric acid was added and heated to boil till the volume is reduced to about 15 – 20 ml by adding conc. Nitric acid and in increments of 5 ml till all the residue is completely dissolved. The mixture is cooled down, transferred and made up to 100 ml using metal free distilled water.

3. Results

Table 1 Physicochemical analysis carried out on selected swimming pools water in hotels and suites in Awka, Anambra State Capital, in Nigeria. (During Dry Season)

S/n	Parameters	Cosmilla	De-Geogold	Sunsurg	Mercy suite	Queen suite	WHO & EPA Limits
1	Appearance	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
2	Odor	Good	Good	Good	Good	Good	good
3	Temperature °C	25.5	24.9	26.20	25.40	26.20	21-30 °C
4	pH	6.00	5.82	5.62	6.14	5.95	7.0-7.8
5	Conductivity µS/cm	82.00	232.00	314.00	242.00	121.00	≤ 2000
6	TDS ppm	40.00	16.00	156.00	120.00	62.00	≤ 1000

7	Turbidity ppm	1.66	2.00	1.55	1.86	2.00	≤ 6
8	Alkalinity ppm	39.50	45.00	32.00	48.50	36.10s	80-120
9	Ca-Hardness ppm	14.00	12.00	8.00	16.00	12.00	200-300
10	Free chlorine ppm	ND	ND	ND	ND	ND	1-3
11	Nitrates ppm	0.03	0.01	0.05	1.00	0.35	1-5
12	Phosphates ppm	ND	ND	0.01	ND	0.03	1-10
13	Sulphates ppm	0.34	0.39	0.55	0.90	0.55	≤ 360
14	Lead ppm	ND	ND	ND	ND	ND	≤ 0.05
15	Cadmium ppm	ND	ND	ND	ND	ND	≤ 0.05
16	Iron ppm	0.30	0.60	0.25	0.19	0.20	≤ 0.30
17	Chromium ppm	ND	ND	ND	ND	ND	≤ 0.05
18	Zinc ppm	ND	0.02	0.03	0.04	0.02	0.01-5.0

S/n	Parameters	Jese suite	Golphin suite	Trig-point	Donvits	Beautiful gate	WHO & EPA Limits
1	Appearance	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
2	Odor	Good	Good	Good	Good	Good	good
3	Temperature °C	25.50	26.00	25.20	26.50	25.50	21-30 °C
4	pH	5.77	6.90	6.20	6.02	7.02	7.0-7.8
5	Conductivity μS/cm	122.00	124.00	282.00	202.00	603.00	≤ 2000
6	TDS ppm	61.00	60.00	140.00	101.00	301.00	≤ 1000
7	Turbidity ppm	1.12	0.82	0.51	0.26	0.55	≤ 6
8	Alkalinity ppm	26.00	36.00	54.00	48.50	100.00	80-120
9	Ca-Hardness ppm	4.00	9.00	46.00	24.00	81.00	200-300
10	Free chlorine ppm	ND	0.02	0.01	ND	0.15	1-3
11	Nitrates ppm	0.15	ND	0.03	0.09	ND	1-5
12	Phosphates ppm	ND	ND	ND	ND	ND	1-10
13	Sulphates ppm	0.70	0.85	0.45	0.32	0.47	≤ 360
14	Lead ppm	0.01	ND	ND	ND	ND	≤ 0.05
15	Cadmium ppm	ND	ND	ND	ND	ND	≤ 0.05
16	Iron ppm	0.32	0.21	0.10	0.15	0.16	≤ 0.30
17	Chromium ppm	0.01	ND	0.01	ND	ND	≤ 0.05
18	Zinc ppm	0.01	0.04	0.02	ND	0.01	0.01-5.0

Table 2 Physicochemical analysis carried out on selected swimming pool water in hotels and suites in Awka, Anambra State Capital, in Nigeria. (During Rainy Season)

S/n	Parameters	Cosmilla	De-Geogold	Sunsurg	Mercy suite	Queen suite	WHO & EPA Limits
1	Appearance	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
2	Odor	Good	Good	Good	Good	Good	good
3	Temperature °C	24.60	25.10	24.50	24.80	26.00	21-30 °C
4	pH	5.50	6.00	5.60	4.90	6.70	7.0-7.8
5	Conductivity µS/cm	92.00	240.00	302.00	420.00	241.00	≤ 2000
6	TDS ppm	45.00	120.00	150.00	210.00	120.00	≤ 1000
7	Turbidity ppm	2.00	1.90	1.43	2.00	1.90	≤ 6
8	Alkalinity ppm	20.50	70.50	81.50	90.10	69.00	80-120
9	Ca-Hardness ppm	19.00	16.00	20.00	10.00	20.00	200-300
10	Free chlorine ppm	0.03	0.01	ND	ND	ND	1-3
11	Nitrates ppm	0.04	0.02	ND	0.05	0.01	1-5
12	Phosphates ppm	0.31	0.25	0.09	0.16	0.60	1-10
13	Sulphates ppm	ND	ND	ND	0.01	ND	≤ 360
14	Lead ppm	ND	ND	ND	ND	ND	≤ 0.05
15	Cadmium ppm	ND	ND	ND	ND	ND	≤ 0.05
16	Iron ppm	0.23	0.40	0.18	0.20	0.21	≤ 0.30
17	Chromium ppm	ND	ND	ND	ND	ND	≤ 0.05
18	Zinc ppm	ND	ND	0.01	0.03	0.02	0.01-5.0

S/n	Parameters	Jese suite	Golphin suite	Trig-point	Donvits	Beautiful gate	WHO & EPA Limits
1	Appearance	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
2	Odor	Good	Good	Good	Good	Good	good
3	Temperature °C	25.00	25.00	24.69	25.10	26.00	21-30 °C
4	pH	5.90	7.20	6.30	6.00	6.80	7.0-7.8
5	Conductivity µS/cm	130.00	116.00	250.00	106.00	580.00	≤ 2000
6	TDS ppm	65.00	58.00	125.00	53.00	289.00	≤ 1000
7	Turbidity ppm	0.60	1.95	0.90	0.45	2.90	≤ 6
8	Alkalinity ppm	40.20	30.00	78.40	54.10	105.00	80-120
9	Ca-Hardness ppm	6.00	15.00	10.00	30.00	90.00	200-300
10	Free chlorine ppm	ND	0.02	ND	0.01	0.01	1-3
11	Nitrates ppm	0.20	0.09	0.27	0.20	0.70	1-5
12	Phosphates ppm	0.50	0.80	0.50	0.30	0.29	1-10

13	Sulphates ppm	0.02	ND	ND	ND	ND	≤ 360
14	Lead ppm	0.01	ND	ND	ND	ND	≤ 0.05
15	Cadmium ppm	ND	ND	ND	ND	ND	≤ 0.05
16	Iron ppm	0.30	0.15	0.24	0.12	0.14	≤ 0.30
17	Chromium ppm	0.01	ND	0.01	0.01	ND	≤ 0.05
18	Zinc ppm	ND	0.40	0.04	ND	ND	0.01-5.0

4. Discussion

Mean temperature of the swimming pools water ranged from 24.5 to 27.8 °C throughout the period of study. The highest temperature was obtained during the dry season while the lowest temperature was observed during the rainy season. They are all within WHO and United State environmental protection agency (EPA) specification. According to (Centre for Environmental Health [9], pools with a temperature of more than 27 °C are more likely to be contaminated than pools with a temperature between 22-27 °C. Increase in temperature encourages the growth of bacteria.

The highest pH value of 7.2 was recorded during the rainy season while the lowest pH value of 5.62 was observed during the dry season. Only Pool Beautiful gate hotel in rainy season was within specification of 7.2-7.8 of pH and the rest of the pools were out of specification. According to LWT [10], high or low pH can affect the efficiency of chlorine to kill harmful germs in pool. Lower pH makes the water more acidic hence swimmers may experience burning eyes, itchy skin and their swimming costumes may get torn easily. Also, a low pH may result in low effectiveness of the chlorine used in the swimming pool water. A low pH may even corrode some of the metallic structures of the swimming pool.

Conductivity and total dissolved solids (TDS) values of swimming pool water varied greatly during the period of study. The conductivity values ranged from 82.00-603.00 µS/cm during the dry season and from 92.50-580.00 µS/cm during the rainy season. The highest conductivity occurred at Beautiful gate swimming Pool (606.00µS/cm) during the dry season and the lowest value was at Cosmilla hotel swimming pool (82.00µS/cm) during the dry season. The TDS ranges from 40.00-301.00ppm throughout the period of study. Though the conductivities and TDS of all the pools conformed to WHO standard of not more than 2000 µS/cm and 1000 ppm respectively, high TDS makes water cloudy and affects visibility of swimmers [11].

Mean total alkalinity, Ca-hardness and free Cl_2 were below the respective 80-120 ppm, 200-300 ppm and 0.5-3.0 ppm WHO and Environmental Protection Agency (EPA) recommended standards. The implication of out of specification of alkalinity is because of its importance in maintaining the recommended pH and water balance levels in a pool. Also, low level of Ca hardness water will etch plaster, pit metal or roughen pool surfaces and cause staining to pool floor [10]. Ca-hardness also affects the water balance of pool. Low level of free Cl_2 across the pools led to having *E. coli* in both rainy and dry season samples and is an indication that there are fecal contaminations in the pool water samples.

The mean Nitrates and the mean phosphates of both seasons were found to be within specification. According to John *et al.*, [10], with nitrate in the pool, you will get algae and other contaminants that won't respond to normal treatment. Nitrates —lock up chlorine, the presence of nitrate in pool water will drastically increase the sanitizer consumption [5]. Nitrate and phosphates in a body of water can contribute to high biological oxygen demand (BOD) levels. High sulphate levels can cause severe damage in concrete pools by attacking cement-based materials. In tiled pools sulphate attacks the tile grouting causing crumbling and expansion of the cement [11]. Though the mean sulphates of both seasons are within specification.

5. Conclusion

The research revealed that the majority of the swimming pools water sampled complied with the world health organization (WHO) and United State environmental protection agency (EPA) standard for recreational water except in the aspect of pH, alkalinity, Ca-hardness, free chlorine, nitrate, and phosphate during both dry and rainy seasons. Zinc anomaly was only observed during rainy season. These few abnormalities may be attributed to lack of awareness of the health implications or poor training of the pool operators.

Disclosure of conflict of interest

No conflict of interest to be disclosed

Compliance with ethical standards

Acknowledgments

I wish to express my profound gratitude to all who contributed in one way or the other to the successful completion of this research work. I appreciate the following lecturers who in one way or the other helped in the completion of this work: Prof. Rob Enemo, Prof A.J Chinweuba, Prof. Sylvia Okonkwo, and Dr. (Mrs) A.M. Ekwonu; May God Almighty bless you all. Finally, my best regards and warm appreciation go to all my family members for their wonderful encouragement, moral and financial support.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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