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# PHYSIOCHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF THREE SWIMMING POOLS IN PORT HARCOURT

***Wemedo S. A. Akani N. P., and Weli A. U.,**

Department of microbiology, Faculty of Science, Rivers State University, Nkpolu Oroworokwo, Rivers State, Nigeria.

***Corresponding Author: Weli A. U.**
Department of microbiology, Faculty of Science, Rivers State University, Nkpolu Oroworokwo, Rivers State, Nigeria.

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## ABSTRACT

The physicochemical and bacteriological quality of three swimming pools in port Harcourt were investigated using standard procedures. Results of the physiochemical parameters were as follows; pH ranged from 5.03±0.23 to 7.43±0.15 before and after chlorination, Temperature ranged from 28.40±0.17 oC to 28.07±0.78 oC, conductivity ranged from 31.67±5.78µS/cm to 110.33±21.13µS/cm, turbidity ranged from 0.10±0.00NTU to 0.20±2.00NTU, salinity ranged from 0.01±0.00% to 0.08±0.01, total dissolved solids ranged from 19.33±2.52mg/l to 142.33±25.69mg/l before, total hardness ranged from 7.53±6.47mg/l to 38.67±0.64mg/l, alkalinity ranged from 7.00±2.65mg/l to 60.67±20.03mg/l, total chlorine and free chlorine recorded no value before chlorination but ranged from 4.40±3.70 to 6.32±0.75 after chlorination. The result of the microbiological analysis are as follows; total heterotrophic bacteria count ranged from 3.5±1.60 to 43.17±20.00x103cfu/ml, total coliform count ranged from 1±1.00 to 21.67±10.27x103cfu/ml, and feacal coliform count ranged from 5.7±3.51 to 33.3±12.50x103cfu/ml. there were no significant differences ($p \geq 0.05$) between most of the parameters analysed. There was no count of Salmonella / Shigella and Vibrio recorded throughout the sampling period. Regular monitoring and thorough education on swimming pool maintenance and usage to avoid contamination of pool and health incrimination is recommended.

**KEYWORDS:** Swimming Pool, Swimming pool water, chlorination, Health risks, Bacteria.

## INTRODUCTION

Swimming is the activity of moving oneself through water using one's arms and legs while buoyed up by the water.[1] Swimming is a popular form of recreation, an important international sport and a healthful exercise that keeps one fit, improves heartbeat, aids blood circulation and development of firm muscles. It is also used in training of astronauts and life guards.[2]

There are many risk associated with swimming pools and similar recreational water environment; there are physical risk, leading to drowning as a result of poor swimming ability, no supervision, poor pool design and maintenance,[3] impact injuries as a result of impact on hard surfaces [4]. The impact may be driven by the participant due to diving, accidents arising from the use of water slides, collision, treading on broken glass and jagged metal.

Physiological risks may arise as a result of acute exposure to heat and ultraviolet (UV) radiation in sunlight, and cumulative exposure to sun for outdoor pool users.[5]

Risk of infection may also arise as a result of inhalation of or contact with pathogenic bacteria, viruses, fungi and protozoans which may be present in water and pool surroundings as a result of feacal contamination, carried by swimmers or naturally present in the water.[6]

The major problem associated with swimming pool water is lack of maintenance and proper care by the pool operators. This could actually be as a result of little or no knowledge about the importance of swimming pool maintenance to meet with the required standard, non-challancy or incompetency of the pool guide; and sometimes, the tendency to economize the chemicals used for disinfecting the pool, either for profit making or as a result of escalating cost. Some over chlorinate the pool thereby making the pool toxic while some under chlorinate the pool, thereby encouraging the growth of microorganisms.[7]

The aim of this research was to investigate some physiochemical and bacteriological quality of some swimming pools in Port Harcourt as to ascertain the extent of compliance to international standards.

## MATERIALS AND METHODS

**Study Area and locations:** The area covered in the research work comprises of Elelenwo in Obio/Akpor L.G. A. Port Harcourt and the location includes; Oxygen pool – located at Akpajo, Preeminence pool – located at Elelenwo and De'elite pool - located at Odolukwu in Elelenwo, Port Harcourt, Nigeria.

**Sample Collection**
Water sample were collected from 3 different swimming pools using sterile bottles. The sample was collected before chlorination when fresh water was just introduced into the pool and after chlorination when the water was chlorinated and used, twice in a month for 3 months. The water was collected aseptically, were put in an ice cooler and then transported immediately to Rivers State University, Nkpolu - Oroworokwo, Port Harcourt for analysis.

**Physicochemical Analysis** pH, Temperature, Conductivity, Salinity and Total Dissolved Solids were taken using Extech pH- Conductivity Exstick II meter calibrated with buffer pH 4.0, 7.0 and 10.0 as well as 84 □S/cm conductivity solutions, Turbidity and Free/Total Chlorine were determined using LaMotte LTC300wi meter. Alkalinity, Total Hardness, determination.[8]

**Microbiological Analysis Estimation of Heterotrophic, Total and Fecal Coliform Count**
The total heterotrophic and coliform bacteria and fecal bacteria count, (THB TCB and FCB) in water were determined using the spread plate technique. This was done as according to the method of APHA.[9] Aliquot (0.1ml) serially diluted volume of water samples were aseptically withdrawn using a sterile pipette and was dropped onto the dry surfaces of the plates containing the various agar; Nutrient, MacConkey, TCBS and SSA freshly prepared, spread all over the agar. And incubated invertedly at temperature of 37$^{o}$C for 24 hours for total heterotrophic and coliform bacteria, and 42$^{o}$C for 24 hours for feacal coliform bacteria estimation.

**Identification of bacterial isolates**
Stock culture of the isolates with different cultural characteristics were made on nutrient agar slant, the purified cultures were morphologically identified by gram staining and were viewed microscopically using x100 oil immersion objective lens. And the following biochemical test were carried out to identify the bacteria isolates; catalase, coagulase, oxidase, citrate, urease, indole, motility, methyl – red and voges – proskauer and sugar fermentation test. These biochemical test was carried out as according to Cheesbrough.and kinika.[10][11]

**Statistical analysis**
The results obtained where subjected to statistical analysis using analysis of variance (ANOVA) using SPSS version 20.

## RESULTS AND DISCUSSION

The result of the physiochemical parameters has revealed that some of the parameters were not in compliance with the international standards, as seen in Table 1.

The three pools were clearly acidic before chlorination, when fresh water was just introduced into the pool, and did not fall within the acceptable limit (7.2 – 8.0) while after chlorination and use, the pH values were in the recommended range (7.2 – 7.6). High pH has been implicated with eye and skin irritation, and drop in disinfection potential of chlorine, while low pH, (acidic pH) effects pools by corroding the metal accessories and staining the pool walls.[2] The three pools were within the WHO and ANSI acceptable limit for temperature (28°C – 32°C), turbidity(0.5NTU), conductivity (20 – 1500), total chlorine (1 – 5mg/l) and free residual chlorine (1 – 3mg/l), [2] except for oxygen pool which was below the acceptable limit after chlorination for total chlorine and free residual chlorine. Meanwhile the three pools did not fall within the acceptable limit for total dissolved solids (250 – 1500mg/l), total hardness (150 – 400mg/l) and alkalinity (60 – 180mg/l). [2][12] This could be as a result of non-cemented nature of the pool. Statistically, there was no significant differences between most of the parameters analyzed. Difference was observed only for total dissolved solids(mg/l) before and after chlorination, before chlorination for conductivity (µS/cm) and total hardness ($CaCO_3$), and finally after chlorination for total chlorine (mg/l).

Results of bacterial populations as presented in table 2 showed high counts of heterotrophic bacteria (3.5±1.60 to 43.17±20.00), coliform bacteria (1±1.00 to 21.67±10.27) as well as feacal coliform bacteria (5.7±3.51 to 33.3±12.50) were observed. The high bacteriological loads in the pools can come from contaminated water sources, fecal or non fecal contaminants from pool users, inefficiency of sanitizing chemicals or incompetency of pool operators in efficient management of the pool. These agrees with Abdou *et al.*[13] However viable cells of *Salmonella*, *Shigella* and *Vibrio* were not detected in the three swimming pools, throughout the three months of sampling. Omotayo *et al*[14] and Onwuakor C.E. et al,[15] also reported *salmonella*/*shigella* free pools.

Ideally, the acceptable limit of coliform bacteria is less than two (>2) and feacal heterotrophic bacteria is 100cfu/ml, coliform bacteria is zero (0).[2] The research finding has revealed that the three swimming pools, were not within the acceptable limits. The results obtained have also revealed that preeminence pool recorded the highest counts of heterotrophic bacteria (43.17±20.00), coliform bacteria (21.67±10.27) and fecal coliform bacteria (33.3±12.50) before and after chlorination, and harbored many bacteria. This high count before chlorination when fresh water was just introduced can be attributed to contaminated water source or contaminated pool environment, while the high counts after

chlorination and use can attributed to factors like; high patronage, inefficiency of the sanitizing agents, incompetency of the pool operators and even unhygienic practices of the swimmers. However, oxygen pool had the lowest counts of heterotrophic bacteria (20.17±17.82), coliform bacteria (16.7±7.76) and fecal coliform bacteria (20.3±11.37) before and after chlorination. Statistically there was no significant difference between the microbiological parameters analyzed except for the total heterotrophic bacteria count.

Generally, the figures obtained after chlorination was significantly higher than the values obtained before chlorination.

**Table 1: Ranges and mean±standard deviation of the physicochemical parameters analysed before and after chlorination.**

| Physicochemical Parameters | In relation to chlorination | Location of Swimming pools | | | WHO Limits |
|---|---|---|---|---|---|
| | | De Elite | Oxygen | Pre-Eminence | |
| Ph | Before | 5.3 - 5.9<br>5.57±0.31[a] | 5.2 - 6.1<br>5.57±0.47[a] | 4.9-6.3<br>5.03±0.23[a] | 7.2 - 8.0 |
| | After | 7.3 - 7.6<br>7.43±0.15[a] | 7.0 - 7.6<br>7.33±0.31[a] | 6.3-8.1<br>7.43±0.99[a] | 7.2 - 7.6 |
| Temperature($^{o}$C) | Before | 28.3 - 28.7<br>28.47±0.2[a] | 28.3 - 28.9<br>28.57±0.31[a] | 28.2 - 28.5<br>28.40±0.17[a] | 28 - 32$^{o}$C |
| | After | 27.7 - 28.6<br>28.23±0.47[a] | 27.6 - 28.7<br>28.20±0.56[a] | 28.2 - 28.7<br>28.07±0.78[a] | |
| Turbidity (NTU) | Before | 0.1 - 0.2<br>0.13±0.06[a] | 0.2 - 0.2<br>0.10±0.00[a] | 0.1 - 0.2<br>0.17±0.06[a] | 0.5NTU |
| | After | 0.2 - 0.2<br>0.20±0.00[a] | 0.2 - 0.2<br>0.20±0.00[a] | 0.2 - 0.2<br>0.20±0.00[a] | |
| Conductivity (µS/cm) | Before | 25 – 35<br>31.67±5.78[b] | 62 - 64<br>63.00±1.00[c] | 86 – 124<br>110.33±21.13[a] | 20 - 1500 µS/cm |
| | After | 85 - 158<br>131.67±40.53[a] | 112 - 127<br>121.00±7.94[a] | 124 – 175<br>144.67±26.84[a] | |
| Salinity (%) | Before | 0.01 - 0.01<br>0.01±0.00[a] | 0.02 - 0.03<br>0.02±0.01[a] | 0.01 - 0.06<br>0.04±0.03[a] | NL |
| | After | 0.05 - 0.07<br>0.06±0.01[a] | 0.04 - 0.08<br>0.06±0.02[a] | 0.07 - 0.09<br>0.08±0.01[a] | |
| Total Dissolved Solids(mgcl) | Before | 17 - 22<br>19.33±2.52[a] | 45 - 48<br>46.67±1.53[b] | 78 – 87<br>82.33±4.51[c] | 250 - 1500mg/l |
| | After | 71 - 116<br>99.00±24.43[a] | 87 - 98<br>91.33±5.86[a] | 127 – 172<br>142.33±25.69[b] | |
| Total Hardness (As CaCo3-mgcl) | Before | 3.8 - 1.5<br>7.53±6.47[a] | 7.1 - 7.9<br>7.57±0.42[a] | 17.0 - 17.5<br>17.27±0.25[b] | 150 - 400mg/l |
| | After | 38.3 - 38.4<br>38.37±0.0577[a] | 37.2 - 38.8<br>38.13±0.83[a] | 38.3 - 39.4<br>38.67±0.64[a] | |
| Alkalinity (As CaCo3-mgcl ) | Before | 8 – 16<br>13.33±4.62[a] | 10 - 45<br>12.33±2.52[a] | 4 – 9<br>7.00±2.65[a] | 60 - 180mg/l |
| | After | 38 – 76<br>60.67±20.03[a] | 40 - 45<br>43.33±2.88[a] | 48 – 68<br>58.00±10.00[a] | |
| Total Chlorine (As CL2 -mgcl) | Before | ND | ND | ND | |
| | After | 0.2 - 7.2<br>4.40±3.70[a] | 7.61 - 7.96<br>7.75±0.18[b] | 4.1 - 6.1<br>5.10±1.00[a] | 1 - 5mg/l |
| Free Chlorine (As CL2 -mgcl) | Before | ND | ND | ND | |
| | After | 0.2 - 4.2<br>2.60±2.12[a] | 5.7 - 7.15<br>6.32±0.75[a] | 1.0 - 4.2<br>2.80±1.64[a] | 1 - 3mg/l |

KEY *means with the same superscript along the rows are not significantly different (p>0.05).

**Table 2: Ranges and mean±standard deviation of the microbiological counts of bacteria before and after chlorination for the 3 months of sampling (X10$^3$cfu/ml).**

| Microbiological analysis | In relation to chlorination | De Elite Pool | Oxygen Pool | Pre- Eminence Pool | WHO Limits |
|---|---|---|---|---|---|
| Total heterotrophic Bacterial Counts (x10$^3$cfu/ml) | Before | 4 – 16 (4.3±3.21$^a$) | 0 – 6 (3.5±1.60$^a$) | 19 – 34 (12.83±3.1$^b$) | < 200/ml |
| | After | 17 – 110 (27.17±24.78 $^a$) | 11 – 76 (20.17±17.82$^a$) | 46 – 126 (43.17± 20.00 $^a$) | |
| Total coliform Counts (x10$^3$cfu/ml) | Before | 1 – 7 (2.33±1.60$^a$) | 0 - 2 (1±1.00$^a$) | 4 – 8 (3.17±1.04$^a$) | < 1/100ml |
| | After | 20 – 43 (17.76±6.25$^a$) | 4 – 34 (16.7±7.76$^a$) | 30 – 67 (21.67±10.27$^a$) | |
| Feacal coliform Counts (x10$^3$cfu/ml) | Before | 2 – 9 (7±4.35$^a$) | 0 – 3 (5.7±3.51$^a$) | 6 – 16 (11.7±4.61$^a$) | 0/100ml |
| | After | 12 – 16 (29±4.35$^a$) | 6 – 20 (20.3±11.37$^a$) | 18 – 28 (33.3±12.50$^a$) | |
| Total salmonella/shigella count (x10$^3$cfu/ml) | Before | 0 – 0 (0.00±0.00$^a$) | 0 – 0 (0.00±0.00$^a$) | 0 – 0 (0.00±0.00$^a$) | 0/100ml |
| | After | 0 – 0 (0.00±0.00$^a$) | 0 - 0 (0.00±0.00$^a$) | 0 – 0 (0.00±0.00$^a$) | |
| Total vibriod count (x10$^3$cfu/ml) | Before | 0-0 (0.00±0.00$^a$) | 0-0 (0.00±0.00$^a$) | 0-0 (0.00±0.00$^a$) | 0/100ml |
| | After | 0-0 (0.00±0.00 $^a$) | 0-0 (0.00±0.00$^a$) | 0-0 (0.00±0.00$^a$) | |

KEY*means with the same superscript along the rows are not significantly different (p>0.05)

A total of 62 isolates belonging to six genera were identified. Bacteria isolated, (table 4.3 and 4.4) were mainly of the enterobacteriaceae family and includes; *klebsiella, Providencia, Proteus* and *E. coli.* This further confirms the outbreak of *E. coli* in swimming pools.[16][17][18] *Bacillus* and *staphylococcus* which are implicated in urinary tract infections, pelvic inflammatory diseases wound infections and septic shock were also isolated. These agrees with the findings of Agbagwa, *et al.*,[19] who isolated similar organisms. *Escherichia coli,* is a pathogenic microorganism, known to cause gastro enteritis, urinary tract infections, diarrheal and even neonatal meningitidis and its presence indicated likely presence of pathogenic microorganisms,[20] *Proteus* has been implicated in urinary tract infections, infections of the ear, respiratory and wound infections, as well as diarrhea in children especially the species of *Proteus mirabilis. Klebsiella* has been one of the organisms that causes pneumonia, necrosis and infection of the blood (septicemia). *Providencia* also causes diarrhea and intestinal disorders. The percentage of occurrence of bacteria (figure 1), has revealed *Bacillus velezensis* has the highest percentage of 31%, followed by Proteus vulgaris which recorded 19%, then *Klebsiella pneumonia* which also recorded 16%, *Staphylococcus scuiri* and *Providencia vermicola* having 13%. *E coli* had the least percentage, and recorded 8%. *Bacillus, E. Coli, staphylococcus* and *proteus* was isolated in the three swimming pools (Table 4), and agrees with Agbagwa[19] where *Bacillus species* appeared in all his sampled location. *Klebsiella* species and *providencia* specie were not isolated in De elite pool and Oxygen pool; while the six bacteria were isolated in preeminence pool. All the organisms Were isolated after chlorination, when the water has been sanitized and used, and is in agreement with[21] who also isolated coliforms in the presence of residual disinfectants in pool. species of *Bacillus, providencia* and *staphylococcus* were isolated before chlorination when fresh water was introduced into the swimming pool.

**Table 3: Occurrences of bacterial in the study swimming pools.**

| Isolates | De Elit es | Oxyg en | Preemine nce | Fq y | % |
|---|---|---|---|---|---|
| *Bacillus velezensis* | + | + | + | 19 | 31 % |
| *Klebsiella pneumonia* | - | - | + | 10 | 16 % |
| *Providencia vermicola* | - | - | + | 8 | 13 % |
| *Proteus vulgaris* | + | + | + | 12 | 19 % |
| *Escherichia coli* | + | + | + | 5 | 8% |
| *Staphylococ cus scuiri* | + | + | + | 8 | 13 % |

**KEY:** + = isolated, - = Not isolated. Fqy = frequency. % = percentage of occurrences

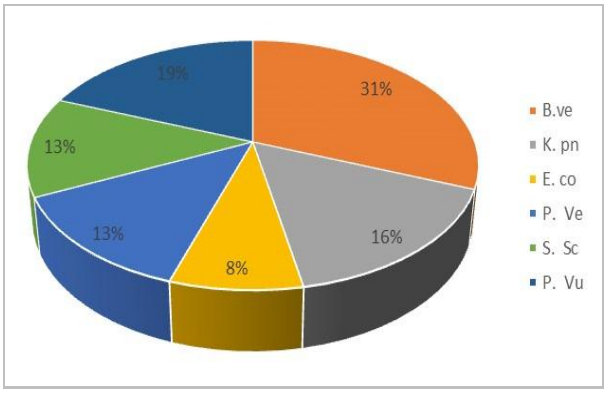


**Figure 1: Percentage distribution of bacterial isolates.**

**Key**: B. ve = *Bacillus velenzensis,* k.pn = *Klebsiella pneumonia,* E. co = *Escherichia coli,* P. ve = *Providencia vermicola,* S.sc = *Staphylococcus scuiri* P.vu = *Proteus vulgaris*

**Table 4: Isolated organisms before and after chlorination.**

| Isolates | Before chlorine | After chlorine |
|---|---|---|
| *Bacillus velezensis* | + | + |
| *lebsiella pneumonia* | + | + |
| *Escherichia coli* | - | + |
| *Staphylococcus sciuri* | + | + |
| *Providencia vermicola* | + | + |
| *Proteus vulgaris* | - | + |

**KEY:** + = isolated, - = Not isolated.

## CONCLUSION

The three pools did not meet some of the physiochemical standard of swimming pool water recommended by World Health Organization and American National Institute. They also exceeded the recommended limit of heterotrophic bacteria count, thermotolerant count and feacal count.
This calls for concern.

## RECOMMENDATION

The operators are therefore advised to follow the guidelines for maintaining standard of pools, also pool users should adhere strictly to good sanitary practices and know that chemical treatment for pools are best supplemented with good hygiene. There should also be pool surveillance by the surveillance team in order to ensure a contaminant free swimming pool, and minimize and control physical, chemical and microbiological hazards in swimming pool.

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