EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 7
Issue: 6
20-29
Year: 2020

ANTIBIOTIC RESISTANCE PATTERN OF BACTERIA ISOLATED FROM RECREATIONAL WATERS IN ADO-EKITI METROPOLIS.

Oluyege J. O.[1], *Orjiakor P. I.[1], Olowomofe T. O., Anyanwu N. O.[2], Ayannuga O. D.[1] and Eze, C. N.[3]

[1]Department of Microbiology, Faculty of Sciences, Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria.
[2]Department of Food Technology, Federal Polytechnic Ado Ekiti, Ekiti State, Nigeria.
[3]Department of Microbiology, University of Nigeria, Nsukka.

***Corresponding Author: Orjiakor, P.I.**
Department of Microbiology, Faculty of Sciences, Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria.

Article Received on 26/03/2020 **Article Revised on 15/04/2020** **Article Accepted on 05/05/2020**

ABSTRACT
Antibiotic resistance patterns of bacteria isolated from Recreational waters in Ado-Ekiti metropolis were investigated in this study. Recreational waters were sampled before and after swimming. The visitors who came to swim were about an average of 4 per day. The Mean Total Bacterial Count was $3.49x10^2$ cfu and the mean Coliform Count was $3.50x10^2$cfu.The pH of the pool waters varied between a range of 6.50 – 7.30 over the sampling period. Pool turbidity range varied over a narrow range of 4.5 – 6.5 NTU, the nitrate range was 2.0 – 5.0 mg/L, while the magnesium hardness range was 20 – 60 mg/L respectively among other parameters. Four gram positive bacteria were isolated namely: *Staphylococcus aureus, Staphylococcus epidemidis, Enterococcus sp., Enterococcus faecalis,* while seven gram negative bacteria were isolated namely: *Pseudomonas aeruginosa, Pseudomonas sp. Escherichia coli, Shigella spp, Shigella dysenteriae, Klebsiella sp., Mycobacterium choloriae*. 16 gram positive bacteria isolates including *Staphylococcus aureus, Staphylococcus epidemidis, Enterococcus spp., Enterococcus faecalis* were resistant to Pefloxacin, Gentamicin, Ampiclox, Cefuroxime, Amoxicillin, Rocephin, Ciprofloxacin, Streptomycin, Septrin and Erythromycin in the range of 4 – 100% resistant pattern, while 35 gram negative bacteria isolates including *Pseudomonas aeruginosa, Pseudomonas spp. Escherichia coli, Shigella spp, Shigella dysenteriae, Klebsiella spp., Mycobacterium choloriae* were resistant to Ofloxacin, Reflacin, Ciprofloxacin, Augmengtin, Gentamicin, Streptomycin, Cephalexin, Naudixic acid, Septrin, Ampicillin in the range of 20 – 100% resistant pattern, some of the isolates were less resistant to Ciprofroxacin. The results of this study indicated that most of the swimming pools studied did not meet the WHO (2011) guidelines for drinking water. This can lead to serious public health implications since *Enterococcus faecalis, Escherichia coli* and *Pseudomonas aeruginosa* which were present in the swimming pools pose health risk as swimmers may accidentally swallow some of the pool water.

KEYS: Antibiotics, Recreational Waters, Swimming pool, Coliform.

1. INTRODUCTION
Water, is undoubtedly, a vital need of man for food and recreation. Water is basic to life on this planet earth, and for man, no substitute has ever been found to serve man in diverse ways that are crucial for mankind's survival and societal advancement as a whole (Alico and Dragonjac, 2006).Water is very essential for the survival of humans and other life forms. It is required for human daily activities such as drinking, cooking, washing, bathing and also for agricultural, industrial and recreational purposes (Centre for Environmental Health, 2005). Water is very basic to life and also functions among others, in, transportation, recreation, and food production processes (Mackereth *et al.,* 2003). Swimming pool waters derive their source from natural waters and their visability is greatly enhanced by the frequency with which the water is changed and the use of chlorine as disinfectants. Normally concentrations of chlorine is maintained at about 1 ppm since chlorine of higher concentrations is usually known to irritate the skin and eyes (Alice, 1977; Fair *et al.,* 2001; Cairns and Dickson, 2003). Cairns and Dickson (2003), indicated that water from swimming pools must be odourless, tasteless and clear with freezing and boiling points at 0^oC and 100^oC, respectively. Although water is a basic requirement for human existence, it can serve as a medium for the transmission of pathogenic microorganisms, if not properly handled, leading to waterborne diseases such as cholera, typhoid fever and infectious hepatitis. The recreational and environmental use of water is increasing in terms of both the nature of the activities being undertaken, and the number of

participants becoming involved (Barna and Kadar, 2012).

Swimming, a popular pastime activity, creates fun and is active and a healthy way to relax and beat the heat in Africa. Swimmers can benefit from cardiovascular workout, an exercise that provides cushion for the joints, protection from the harsh impact normally associated with most forms of exercise, movement that gets the heart pumping and muscles working against the resistance of the water (Evans, 2007). Regular swimming builds endurance, muscle strength and cardio-vascular fitness. It can serve as a cross-training element to the regular workouts. The pool can sometimes serve as a warm-up agent prior to a dry land workout session. Swimming with increasing effort to gradually increase the heart rate and stimulate muscle activity is easily accomplished in the water. After a dry land workout, swimming a few laps can help the cooling down process and blood circulation to the muscles to help the recovery and relaxation as one glides through the water (Luebbers, 2012). There are other psychological benefits to swimming; gaining a feeling of well-being, refreshed after every swimming and ready to go on with the rest of the day's activities. Many swimmers find an in-direct benefit from swimming. Swimmers develop life skills such as sportsmanship, time-management, self-discipline, goal-setting, and an increased sense of self-worth through participation in the sport. Swimmers seem to do better in school, in general terms, than non-swimmers.

Swimming does burn calories at a rate of about 3 calories a mile per pound of bodyweight. However, many swimmers do not swim that quickly, and many cannot swim for a long distance or duration, so swimming to lose weight is not always the best plan. Swimming exercises almost the entire body - heart, lungs, and muscles - with very little joint strain. It is great for general fitness, just not a great way to drop excess weight. Swimming for pleasure has been practiced by many land animals and humans, and records of the pleasure of immersion in water go back several thousand years ago (Sule and Oyeyiola, 2010). A swimming pool is an artificially enclosed body or basin or concrete tanks or large paved holes containing water constructed, designed, modified, or improved intended for swimming, diving, recreation or instruction and water based recreation and includes condominiums, schools/institutions, motels and hotels (Kuzgunkaya and Yildirim, 2010). Most people choose swimming pools over rivers and streams for its supposedly hygienic nature. Swimming pools have become one of the main side attractions in the marketing of tourism in Nigeria and Ghana, thus, they can be found in hotels, guest houses, restaurants, club houses and tertiary institutions, among others.

There are set of operational rules and principles guiding each swimming pool which ensures the portability of the swimming pool and good hygiene maintenance. Some of these operational rules and principles stipulate that before entering the pool, each bather showers with soap; and those having any skin disease are disallowed from using the facility. (Cruickshank *et al.*, 1975) indicated that pathogenic microorganisms may infect swimming pools directly or indirectly through the entry into the pool by sewage, soil, contaminated air, dust, and rain water.

Furthermore, swimming pool users with infections may pollute the pool water with micro-organisms, through secretions from the nose and throat, skin, mouth, urine, accidental faecal release or by contaminated objects and clothes, airborne contamination, incoming water from unsanitary source, and droppings from birds (Sule and Oyeyiola, 2010). Polluted pool water results in diarrhoea, ulcers of the skin, upper respiratory infections, gastro-enteritis, conjunctivitis, trachoma, cholera, dysentery, eczema infections of the ear like otitis media and skin diseases (Cairncross *et al*., 2000; UNDP, 2004). *Pseudomonas aeruginosa, Mycobacteria spp, and Staphylococcus aureus* are some of the non-enteric pathogenic micro-organisms commonly found in pools. Poor sanitary conditions and improper disinfection of swimming pools can lead to a serious drawback in the maintenance of public health (Farthing, 2000).

Recreational use of water can deliver important benefits to health and well-being, yet, there may also be adverse health risks associated with recreational use, if the water is polluted or unsafe. For most swimming pools in Ado-Ekiti, the pool's capacity is determined by the number of people present for an occasion. There is little data if any on the quality of water in swimming pools in Ado-Ekiti.

An increasing number of waterborne diseases outbreaks caused by *Cryptosporidium* and *Giardia* have been documented worldwide which depict a trend in which protozoa and viruses are replacing bacterial pathogens as agents of primary concern in waterborne diseases (Bushon and Francy, 2003). Oocysts and cysts of parasitic protozoans are relatively resistant to conventional water treatment (disinfection) and survive longer in the environment posing a public health risk. In view of the serious health risk posed by swimming pools, there is a sense of urgency to identify the type of microorganisms in our pools with emphasis on protozoan so that appropriate measures could be taken to ensure that health risks related to parasites in pool water can be significantly reduced or minimized if not completely eliminated.

The study was conducted to determine the microbial quality, antibiotics resistance and the physicochemical analysis in swimming pools before and after swimming in Ado-Ekiti.

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted in Ado-Ekiti, Ekiti State Nigeria.

2.2. Sample collection

Twelve swimming pools all located in different areas of Ado-Ekiti metropolis in southwestern Nigeria were randomly selected for assessment of their physicochemical and microbiological qualities. A survey of hotels was conducted and twelve hotels with swimming pools were selected based on the consent of the management of the hotels and accessibility. The selected swimming pools included: AA Hotel, BB Hotel, AB Hotel, CC Hotel, AC Hotel, BC Hotel, DD Hotel, DC Hotel, AD Hotel, BD Hotel, CD Hotel, FF Hotel.The samples were collected at two different times of the day (Monday and Tuesday). The first batch (before swimming) was collected from 9:00 am to 12:00 pm and the second batch (after swimming) was collected from 5pm to 6:30pm. For each of the twelve selected swimming pools, two (2) separate 1.5 L water samples were collected from three different sections of each specific pool of which samples collected from each section were in duplicates. For the two samples collected, one was used for physiochemical analysis and the other for microbial analysis. The water samples were collected into sterile sampling bottles with little amount of sodium thiosulphate which served as inhibitor of chlorine action, properly corked, placed on ice and transported to the laboratory within twenty-four (24) hours for analysis. The sampling was done within two months September 2018 to October 2018. A total of 24 samples were collected from the entire sampling site during the study. Laboratory analyses were carried out on all the pool samples collected from the field and brought to the laboratory.

2.3 Determination of physicochemical parameters

The temperature and pH of the water sample were recorded at the point of collection using thermometer and pocket Digital pH meter respectively. Other parameters such as total dissolved solid (TDS), Total hardness, chlorides, conductivity, calcium hardness, magnesium hardness, and total dissolved solid; were estimated in the laboratory, using standard procedures. Ultra-violet spectrometer was used for the determination of nitrate concentrations (APHA, 2002)

2.4 Bacteriological analysis of sample

The bacterial counts and isolation of the colonies were done using a battery of media, namely; plate count agar (PCA), nutrient agar (NA), MacConkey agar (MA), *Salmonella-shigella* (SSA) and Eosin Methylene blue agar (EMB). All the media used were weighed out and prepared according to the manufacturer's instructions. A serial dilution was carried out using 1 ml of the swimming pool water samples up to 10^6. From the diluted samples, 0.1 ml was taken from of 10^2 to 10^6 aseptically plated on the sterile molten agar media, using the pour plate techniques, before incubating (after setting) in an inverted position aerobically at 28^0C for 24-48 hours. After the incubation period, the numbers of colonies between 40-300 were counted and recorded appropriately with careful attention to details. The counted colonies were subculture by streaking in another plate containing solidified nutrient agar for the purpose of isolate and incubated in an inverted position for 48hours. After the incubation period, the colonies were aseptically transferred into slant bottles and later subjected to various colonial morphological and biochemical characterization tests to determine the identity of the bacteria isolates using the Bergey's Manual of Determinative Bacteriology as a guide (Buchanan and Gibbon, 1974).

2.5 Antibiotic sensitivity test

The Kirby-Bauer technique was adopted in determining the antibiotic sensitivity test using commercially gram-positive and gram-negative discs. The gram-positive discs used includes: PEF, GEN, APX, ZIN, AMX, ROC, STR, SXT, and ERY antibiotics, while that of gram-negatives included SXT, CHM, SPX, AMX, CPX, AUG, GEN, PEF, OFX and STR antibiotics. The cultured medium used was Mueller Hinton Agar (MHA). After culturing the test bacterial isolates for 18-24 hours in peptone water, 0.5ml of the bacterial culture was evenly spread on approximately 25ml MHA plates. And left to dry for 15-30 minutes, before adding the anti- biotic discs on the agar surface firmly using sterile forceps. The plates were then incubated at 37^0 C for 24 hours. After the incubation period, the zones of inhibition were measured in millimeters and interpreted as reported earlier (CLLS, 2014)

3. RESULTS AND DISCUSSION

The physical and chemical composition, along with the bacteriological analysis of the parameters studied from the twelve swimming pools from Ado-Ekiti are presented in Table 1. It was found that all the water samples were clear and colourless.The different parameters examined for each of the hotel showed varying degree of values. On the average, it was observed that values for turbidity, temperature and total dissolved solids were above the WHO and EPA permissible limit after use.

The pH of water is an important parameter in swimming pools necessary for the efficient disinfection and coagulation, prevention of the pool fabric from damage and also ensuring the comfort of users (Thickett *et al.*, 2002). The average pH values recorded in all the twelve sampling locations before after use were all within WHO and EPA permissible limit. The pH has a direct impact on the recreational users of water only at very low or very high values (American Public Health Association, 2005). Problems of high pH in swimming pools include primary irritation of the skin such as dry skin, itchy skin and scalp, burning eyes and nose, drop in disinfection potential of chlorine resulting in bacterial growth. Low

pH may have effects on the pools such as in corroding of the metal pool accessories, staining resulting from corrosion, burning eyes and skin, destroying of swim wears and accessories (American Public Health Association, 2005; Bilajac *et al*., 2012). Many of the outbreaks related to swimming pools and similar environments have occurred because disinfection was not applied nor was inadequate (WHO, 2006).

Chlorine is the most common disinfectant used for disinfecting the swimming pool against cross bather infections. Chlorine may be supplied to the pool water in a variety of forms including chlorine gas (Cl_2), sodium hypochlorite solution (NaOCl) or calcium hypochlorite (Sule *et al.*, 2010)**.** The free Chlorine levels recorded in Samples collected before swimming were higher than the values recorded in samples collected after swimming. This could be as a result of formation of chloramines in the samples collected after swimming. Chlorine reacts rapidly with urea, ammonia, and other nitrogen containing wastes such as sweat and urine introduced by bathers into the water, thus forming chloramines (monochloramine, dichloramine and nitrogen trichloride). Urea hydrolysis result in the release of more ammonia in the water and nitrogen containing amino acids undergo chemical reactions with hypochlorite producing organic chloramines which causes eye irritation and high chlorine odour (Isaak and Morris, 1980). The low residual chlorine level in some of the pools may be as a result of inadequate chlorination or the high presence of bacteria in them.

Colour in water may be attributed to human activities, peat, plankton, vegetation and natural metallic ions. Colour in swimming pools may originate from decomposition of organic matter and other contaminants of different materials in varying concentrations. Colour interferes with penetration of light in the pool and may also hamper oxygen absorption from the atmosphere (Walakira, 2011). The study reveals that all the swimming pool remains colourless in all samples before and after use of the pool.

Season time of the day, cloud cover, air circulation, latitude, altitude and the depth of the pool has effect on the temperature of swimming pool water. In effect, temperature affects physical, chemical and biological processes in the pool water. As temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilization of substances from the water (Chapman, 1996). The temperature values obtained before swimming were within the recommended range of 22^0C - 26^0C by WHO (2011). This conforms to results of various studies by Edimeh *et al*. (2011), Manilla and Frank (2009) and Clarke *et al*. (2004). The higher values of temperature observed in the study could be attributed to the various body temperature of the swimmer. Also, temperature could be affected by the weather due to the different times of sampling from the pools (Fritz, 2001). This study was consistent with other studies done by Leoni *et al.* (2001) and Leoni *et al.* (1999).

All the conductivity values recorded during the study before and after swimming samples were below the WHO guideline of 250µS/cm for drinking water, except AB Hotel and Motif funland which was above the WHO guideline. The low conductivity recorded in all the sampling locations indicated contaminations due to dissolved ions in the pools. This study was similar to the research done by Marshall and Winterbourn (1979). High conductivity in a sampling location (Midas Hotel) could be related to the high concentrations of dissolved ions in the swimming pools since the source of swimming pool water is ground water with dissolved salts. These could be attributed to differences in geochemical conditions and soluble ions in the locations analysed (Dharmappa *et al.*, 2000). Some values of total dissolved solids (TDS) recorded for both before and after swimming samples were within the acceptable range of 500 mg/l recommended by WHO for drinking water. However, before swimming samples were generally lower than after swimming samples and this may be due to the presence of inorganic salts and other dissolved materials in the pool (EPA, 1991). The values in this study conform to that reported byAremu *et al.* (2011).

It was observed that the turbidity values for samples collected before swimming were lower than the samples collected after swimming. All the mean values obtained in the samples collected before swimming were low except BB Hotel, AB Hotel, DD Hotel, AD and CD Hotel which recorded values of 5.5 respectively, others were below the WHO (2011), guideline of 5 NTU for drinking water. While, the values obtained for samples collected after swimming were higher than the WHO (2011), guideline for drinking water with the highest recorded value of 6.5NTU occurs at BB Hotel, AB Hotel, DD Hotel, AD and CD Hotel sampling locations. This may be attributed to the organic matter and colloidal matter discharged from bathers during swimming, maybe majority of swimmers do not shower before swimming. This study is similar to a work done by Lamb (1985), which also recorded high turbidity values. The greater the turbidity of the swimming pool water, the higher the risk of gastro-intestinal diseases (Eric and Catherine, 1997).

Table 1: Physiochemical parameters of some selected swimming pools water samples in Ado – Ekiti.

PARAMETERS	RANGE BU AU	MEAN VALUES BU AU	LOWEST VALUES BU AU	WHO and EPA Permissible Limit
Transparency	-	-	-	**ND**
Colour	-	-	-	**ND**
Turbidity (NTU)	4.5 – 6.5	4.91 – 5.79	4.5 – 5	5 NTU
Temperature (^{0}C)	20 – 30	24.2 – 26.2	23 – 25	26^{0}C
Ph	6.50 – 7.30	6.75 – 7.13	6.56 – 7.03	8.50
Chlorine (mg/L)	0.5 – 2.0	1.25 – 0.82	0.9 – 0.7	3 (mg/L)
Nitrate (mg/L)	2.0 – 5.0	3.23- 4.05	2.4 – 3.2	5 (mg/L)
Conductivity (µs/cm)	40 – 300	103.5 – 117.3	40 – 44	250.00 (µs/cm)
Total Hardness (mg/L)	50 – 120	78.8 – 93.1	52 – 74	150 (mg/L)
Calcium Hardness (mg/L)	30 – 80	45.4 – 56.5	32 – 43	150 (mg/L)
Magnesium Hardness (mg/L)	20 – 60	33.4 – 42.4	20 – 31	150 (mg/L)
Total Dissolved Solids (mg/L)	300 – 900	499 – 653	340 – 394	500 (mg/L)

Key: BU-Before use, AU-After use.
ND- Not detected.

Table 2 shows the total bacterial count (TBC) of some selected swimming pool water samples from Ado-Ekiti. It was found that TBC was higher after use than before use. It also revealed that CD hotel had the highest (TBC) use and AA hotel had the least. The mean total bacterial counts (TBC) for all the water samples recorded in the twelve sampling locations were generally high. Both samples collected before and after swimming s recorded high values of TBC which exceed the EPA and WHO permissible limit for drinking water. The high total bacterial count is indicative of the presence of high organic and dissolved salts in the water. The primary sources of these bacteria in water are animal and human wastes. These sources of bacterial contamination include surface runoff, pasture, and other land areas where animal wastes are deposited. Additional sources include seepage or discharge from septic tanks, sewage treatment facilities and natural soil /plant bacteria (EPA, 2002).

Table 2. Total bacterial count (TBC) of swimming pool water samples.

S/N	SAMPLE SITE	BEFORE USE		AFTER USE	
		10^3	10^4	10^3	10^4
1.	AA Hotel	40	35	129	112
2.	BB Hotel	59	63	170	145
3.	AB Hotel	43	55	122	140
4.	CC Hotel	50	66	103	99
5.	AC Hotel	44	57	87	78
6.	BC Hotel	90	85	155	112
7.	DD Hotel	50	20	82	112
8.	DC Hotel	74	71	128	122
9.	AD Hotel	76	62	92	85
10.	BD Hotel	95	52	157	102
11.	CD Hotel	96	87	120	110
12.	FF Hotel	75	59	122	128
13.	Mean values	66	59.3	122.25	101.91
14.	Range values	40 – 100	20 -90	80 – 170	70 – 150
15.	Lowest values	40	20	82	78

Table 3 shows the total coliform count (TCC) of some selected swimming pool water samples from Ado-Ekiti. From the results, the (TCC) was higher after use than before use, with CD hotel samples yielding the highest (TCC), while FF hotel gave the least counts.Coliforms originate most often in the intestinal tract of warm blooded animals, including humans. The routes of entry into the human body by pathogens include the skin and more commonly by the ingestion of drinking water and water from swimming pools (Chapra, 1997). Swimming pools with significant numbers of coliforms is a strong indication that there is deficiency in the treatment of the pool water or the source of raw water is inadequately protected (Borchardt and Walton, 1971). The mean values of TBC and TCC recorded in the twelve sampling locations were generally high. Both before and after swimming water samples recorded high values of TC and TCC. The mean values for TBC and TCC were above the recommended value of zero for WHO (2011), guideline for drinking water.

Table 3: Total coliform count (TCC) of swimming pool water samples.

S/N	SAMPLE SITE	BEFORE USE		AFTER USE	
		10^3	10^4	10^3	10^4
1.	AA Hotel	94	85	170	150
2.	BB Hotel	50	45	100	95
3.	AB Hotel	67	52	112	101
4.	CC Hotel	52	45	122	105
5.	AC Hotel	66	56	134	122
6.	BC Hotel	79	57	125	112
7.	DD Hotel	80	74	129	54
8.	DC Hotel	66	59	96	75
9.	AD Hotel	94	70	99	94
10.	BD Hotel	68	72	68	104
11.	CD Hotel	112	100	170	129
12.	FF Hotel	34	29	78	64
13.	Mean values	71.83	62	116.08	100.41
14.	Range values	30 – 120	20 -100	60 – 170	50 – 150
15.	Lowest values	34	29	68	54

The findings on *Escherichia coli* count of some selected swimming pool water samples from Ado-Ekiti are presented in Table 4. From the results, the *E coli* count was higher after use than before use; BB hotel and BC Hotel had the highest *E . coli* while BD hotel had the least. *Escherichia coli,* a human pathogen, were encountered in all the swimming pools. This was probably due to faecal contamination by cold-blooded and warm-blooded organisms. Studies by Stanier *et al.* (1987), and also by Carbell *et al.* (1975), showed that, swimmers usually contribute *Escherichia coli* species in the pools. Robinton and Mood (1986), suggested similar occurrence in a report on quantitative and qualitative appraisal of microbial pollution of water by swimmers. However, Bonde (1985) and Itah *et al.* (1996), indicated that the presence of *E. coli* in water strongly suggests that the source of pollution is close or near to the sampling site. The presence of *E. coli,* is an indicator bacteria. The occurrence of this condition may constitute a health hazard to the public since pool bathers may accidentally ingest contaminated water from pools in the course of swimming in which case outbreak of cholera, typhoid and gastroenteritis and diarrhoea is the result (Itah *et al.*, 1996; Okafor, 1985). The occurrence of *E. coli* in pools also indicates poor pool management and lack of thorough disinfection of the pool and insufficient or lack of safeguarding measures of the raw water source (Barrell *et al.*, 2000). This is probably due to the fact that the pipes used for water distribution from the source to the pools were rusty thus allowing seepage of microbial contaminants in the pools (Borchardt and Walton, 1971). Some of this pools considered in the study recorded high levels of *Escherichia coli* that do not meet the recommended levels set by the WHO for swimming pools. This is because according to Edberg *et al.*, (2000), water sample from swimming pools should not have any organism of coliforms in a 100 ml of water since most swimmers swallow some of the pool water.

Table 4: *Escherichia count* (TBC)of swimming pool water samples.

S/N	SAMPLE SITE	BEFORE USE		AFTER USE	
		10^3	10^4	10^3	10^4
1.	AA Hotel	83	53	109	79
2.	BB Hotel	93	70	73	51
3.	AB Hotel	73	61	80	62
4.	CC Hotel	80	57	103	93
5.	AC Hotel	50	41	81	58
6.	BC Hotel	93	63	104	59
7.	DD Hotel	87	76	63	51
8.	DC Hotel	73	61	80	62
9.	AD Hotel	90	57	103	93
10.	BD Hotel	40	31	81	58
11.	CD Hotel	72	66	54	46
12.	FF Hotel	89	76	66	57
13.	Mean values	76.91	59.33	83.91	64.5
14.	Range values	40 – 95	30 – 80	50 – 110	45 – 95
15.	Lowest values	40	31	54	46

The information depicted in Table 5 shows the biochemical test of some selected swimming pool water samples from Ado-Ekiti. *Enterococcus faecalis, Escherichia coli* and *Pseudomonas aeruginosa,*

Pseudomonas spp., *Staphylococcus aureus*, *Shigella spp.*, *Klebsiella spp.*, *Mycobacterium cheloriae*were the suspected organisms isolated from all the water samples. A total of 51 bacterial isolates were characterized. Among the characterised bacteria, the frequency of their isolation were n *Escherichia coli* (n=24). *Enterococcus faecalis* (n-5), *Pseudomonas* spp. (n=6), *Staphylococcus aureus* (n=8), *Shigella spp.*. (n=2), *Staphylococcus Epidermidis* (n=2), *Klebsiella spp*. (n=1), *Mycobacterium cheloriae* (n=1), and *Pseudomonas aeruginosa* (n=1) and *Enterococcus* spp. (n=1) (Table 5).

Table 5: Characterization of bacterial isolates from swimming pool water samples.

Sample Code	Grams Reaction	Spore Staining	D-Glucose	Catalase	Oxidase	V.P Test	Citrate	M.A	Urease	Indole	Motility	Suspected Organisms
CC BU 1	-	-	+	+	-	-	-			+	+	*Escherichia coli*
CC BU 2	-	-	+	+	-	-	-			+	+	*Escherichia coli*
CC BU 3	-	-	+	+	-	-	-			+	+	*Escherichia coli*
CC AU 1	-	-	+	+	-	-	-			+	+	*Escherichia coli*
CC AU 2	+	-	+	+	-	+		+	+	-	-	*Staphylococcus aureus*
CC AU 3	-	-	+	+	-	-	-			+	+	*Escherichia coli*
BB BU 1	-	-	+	-	+	+	-	+	+	-	-	*Shigella spp*
BB BU 2	-	-	+	+	-	-	-	+	-	+	-	*Shigella dysenteriae*
BB BU 3	-	-	+	+	-	+	+	-	+	-		*Klebsiella spp.*
BB AU 1	+	-	+	-	-	+	-	-	-	-	-	*Enterococcus spp.*
BB AU 2	+	-	+	+	-	-	-	+	+	-	-	*Staphylococcus aureus*
AC BU 1	-	+	-	+	-	-	-			-	-	*Escherichia coli*
AC BU 2	+	-	-	-	-	-	+			+	-	*Enterococcus faecalis*
AC AU 1	-	-	-	+	+	-	+	-	-	-	+	*Pseudomonas spp.*
AC AU 2	-	+	-	+	+	+	+	+	-	+	-	*Escherichia coli*
AA BU 1	-	+	-	+	-	+	-	-	-	+	-	*Mycobacterium cheloriae*
AA BU 2	-	-	+	+	-	-	-			+	+	*Escherichia coli*
AA AU 1	-	-	-	+	+	-	+	-	-	-	+	*Pseudomonas spp.*
AA AU 2	-	-	-	+	+	-	+	-	-	-	+	*Pseudomonas spp.*
AB BU 1	+	-	+	+	-	+	+	+	+	-	-	*Staphylococcus aureus*
AB BU 2	+		+	+	-	+	-	-	+	-	-	*Staphylococcus epidemidis*
AB AU 1	+	-	+	+	+	+	+	+	+	-	-	*Staphylococcus aureus*
MS AU 2	+	-	+	+	-	+	+	+	+	-	-	*Staphylococcus aureus*
BC BU 1	+	-	+	+	-	+	+	+	+	-	-	*Staphylococcus epidemidis*
BC BU 2	+	-	+	+	-	+	+	+	+	-	-	*Staphylococcus aureus*
BC AU 1	+	-	-	-	-	+	-	-	-	+	-	*Enterococcus faecalis*
BC AU 2	-	+	-	+	+	+	+		+	-	-	*Escherichia coli*
DD BU 1	-	+	-	+	+	+	+		-	+	-	*Escherichia coli*
DD BU 2	-	+		+	+	+	+		-	-	-	*Escherichia coli*
DD AU 1	-	-	+	+	-	-	-		+	-	+	*Pseudomons aeruginosa*
DD AU 2	+	-	+	-	-	-	+		-	-	-	*Enterococcus faecalis*
DC BU 1	-	+	-	+	+	+	+		-	+	-	*Escherichia coli*
DC BU 2	-	-	-	-	-		+		-	-	-	*Escherichia coli*
DC AU 1	-	-	-	-	+	-	-	-	+	-	-	*Escherichia coli*
DC AU 2	-	+	-		+	+	+		-	+	-	*Escherichia coli*
AD BU 1	-	+	+	+	+	+	+	-	+	+	-	*Escherichia coli*
AD BU 2	-	+	-	+	+	+	+	-	-	+	-	*Escherichia coli*
AD AU 1	-	+	-	+	+	+	+	-	-	+	-	*Escherichia coli*
AD AU 2	+	-		-	-	-	+	-	-	-	-	*Enterococcus faecalis*
BD BU 1	-	+	-	+	+	+	+	-	-	-	-	*Escherichia coli*
BD BU 2	-	+	-	+	+	+	+	-	-	-	-	*Escherichia coli*
BD AU 1	+	-	+	+	-	+		+	+	-	-	*Staphylococcus aureus*
BD AU 2	+	-	+	+	-	+		+	+	-	-	*Staphylococcus aureus*
CD BU 1	-	-	-	+	+	-	+	-	-	-	+	*Pseudomonas spp.*
CD BU 2	-	+	-	+	+	+	+	+	-	+	-	*Escherichia coli*
CD AU 1	-	-	+	+	-	-	-		+	-	+	*Pseudomonas aeruginosa*
CD AU 2	+	-	+	-	-	-	+		-	-	-	*Enterococcus faecalis*
FF BU 1	-	+	-	+	+	+	+		-	+	-	*Escherichia coli*
FF BU 2	-	-	-	-	-		+		-	-	-	*Escherichia coli*
FF AU 1	-	-	+	+	-	-	-			+	+	*Escherichia coli*
FF AU 2	-	-	-	+	+	-	+	-	-	-	+	*Escherichia coli*

The results on the antibiogram of the bacterial isolates are presented in Table 6 and 7. It shows that 16 of the Gram positive bacteria isolates, namely; *Staphylococcus aureus*, *Staphylococcus epidemidis*, *Enterococcus* spp.

and Enterococcus faecalis were resistant to Pefloxacin, Gentamicin, Ampiclox, Cefuroxime, Amoxicillin, Rocephin, Ciprofloxacin, Streptomycin, Septrin and Erythromycin in the range of 4 – 100% resistant pattern (Table 6). However, 35 of the Gram negative bacteria isolates, namely *Pseudomonas aeruginosa, Pseudomonas spp. Escherichia coli, Shigella spp, Shigella dysenteriae, Klebsiella spp. and Mycobacterium cheloriae* were resistant to Ofloxacin, Reflacin, Ciprofloxacin, Augmengtin, Gentamicin, Streptomycin, Cephalexin, Naudixic acid, Septrin, Ampicillin in the range of 20 – 100% resistant pattern. Moreover, some of the isolates were less resistant to Ciprofroxacin (Table 7). Overall, the antibiotic resistant results from the study highlight the need to determine the prevalence of antibiotic susceptibility genes in the swimming pool water and dissemination of susceptible genes among the pathogen. Resistance to an antibiotic develops in no time and hence, is a big matter of concern (Levy *et al.*, 1998). With the improvement of technology, more people are now aware of the ill-effects caused by resistance to the available drugs, however, very few take pro-active steps to curb the resistance by not over using the antibiotics (Grigoryan *et al.*, 2007). In the developing world, almost all the antibiotics are available over the counter and can be bought without any medical prescription which is one of the most important factors in causing the resistance. Therefore, if the resistance to the antibiotics needs to be curbed, the only way shall be to educate the patients and the general public.

Table 6: Gram-positive bacterial isolate antibiotic resistance pattern in %.

S/N	Antibiotics	*S. aureus* (n=8)	*S. epidemidis* (n=2)	*Enterococcus* spp. (n=1)	*E. faecalis* (n=5)
1.	Pefloxacin	0 (0)	0 (0)	1 (100)	2 (40)
2.	Gentamicin	0 (0)	0 (0)	1 (100)	1 (20)
3.	Ampiclox	0 (0)	0 (0)	1 (100)	1 (20)
4.	Cefuroxime	4 (50)	2 (100)	1 (100)	1 (20)
5.	Amoxacillin	2 (25)	1 (50)	0 (0)	1 (20)
6.	Rocephin	2 (25)	2 (100)	1 (100)	1 (20)
7.	Ciprofloxacin	0 (0)	0 (0)	1 (100)	2 (40)
8.	Streptomycin	2 (25)	0 (0)	1 (100)	3 (60)
9.	Septrin	2 (25)	0 (0)	1 (100)	1 (20)
10.	Erythromycin	0 (0)	0 (0)	1 (100)	2 (40)

Valves in parenthesis are % antibiotic resistance

Table 7: Gram-negative bacterial isolate antibiotic resistance pattern in %.

S/n	Antibiotics	*P. aeruginosa* (n=1)	*Pseudomonas* spp. (n=6)	*E. coli* (n=24)	*S. typhii* (n=1)	*S. dysenteriae* (n=1)	*Klebsiella spp.* (n=1)	*M. cheloriae* (n=1)
1.	Ofloxacin	0 (0)	3 (50)	4 (16.64)	0 (0)	1 (100)	1 (100)	1 (100)
2.	Reflacin	0 (0)	6 (100)	11 (99.99)	1 (100)	1 (100)	0 (0)	0 (0)
3.	Ciprofloxacin	1 (100)	3 (50)	4 (16.64)	0 (0)	0 (0)	0 (0)	0 (0)
4.	Augmentin	0 (0)	0 (0)	1 (4.16)	0 (0)	1 (100)	0 (0)	1 (100)
5.	Gentamicin	0 (0)	2 (33.3)	3(12.48)	1 (100)	1 (100)	0 (0)	1 (100)
6.	Streptomycin	0 (0)	1 (16.67)	4 (16.64)	0 (0)	0 (0)	1 (100)	1 (100)
7.	Cephalexin	1 (100)	0 (0)	3((12.48)	1 (100)	0 (0)	0 (0)	1 (100)
8.	Nalidixic acid	0 (0)	6 (100)	4 (16.64)	1 (100)	1 (100)	0 (0)	1 (100)
9.	Septin	0 (0)	0 (0)	1 (4.16)	1 (100)	0 (0)	0 (0)	0 (0)
10.	Ampicillin	0 (0)	6 (100)	3 ((12.48)	1 (100)	1 (100)	1 (100)	1 (100)

Valves in parenthesis are % antibiotic resistance

4. CONCLUSION

In conclusion, the results of this study indicated that most of the swimming pools studied, did not meet the WHO (2011), guidelines for drinking water. This can lead to serious hazard to the health of the public from a bacteriological perspectives since *Enterococcus faecalis, Escherichia coli* and *Pseudomonas aeruginosa, Staphylococcus spp* and other organisms which were present in the swimming pools pose health risk as swimmers may accidentally swallow some of the pool water. The significant number of antibiotic resistant bacteria in the swimming pools is a strong indication that there is deficiency in the treatment of the pool water or the source of raw water is inadequately protected.

5. Recommendation

The following recommendations are made based on the outcome of this study.

i. Swimming pools operators should use the required disinfection reagent allowed rather than super-chlorination and the disinfectant should be thoroughly mixed in the pools. Stringent and modern inspection procedures must be adopted by the Ministry of Health and used to monitor pool water

treatment especially during the weekends and public holidays when the pools are most heavily patronised.

ii. Continuous monitoring of swimming pools for water quality indicators, (pH, temperature, conductivity, turbidity) especially when the number of users increases to 20 or more in the pool.

iii. Poster signs should be enforced in every swimming pool to educate and enlighten swimmers about good sanitary habits since some of the pools did not have these signs posted at the pool side.

iv. Health authorities should regularly monitor the pools for compliance with regulations and also swimmers must be encouraged to shower and disinfect their foot before swimming to minimize soil contamination since most people do not shower or wash their feet before swimming.

v. Finally, swimmers should be cautioned about swimming in pools if they are suffering from gastroenteritis or other diseases.

REFERENCES

1. Alice, L. S. (1977). Principles of Microbiology. *London: CV Mosby;* 8 (8): 661-710 Retrieved from *http://www.ijastnet.com/journals/Vol_2*.
2. Alico, R. K. and Dragonjac, M. F. (2006). Evaluation of culture media for recovery of *Staphylococcus aureus* from swimming pools. *Applied Environmental Microbiology*, 51: 699-702.
3. Aremu, M. O., Olaofe, Ikokoh, P. P. and Yakubu, M. M. (2011). Physicochemical characteristics of stream, well and borehole water sources in Eggon, Nasarawa State, *Nigeria. Journal of Chemical Society of Nigeria*, 36(1): 131-136.
4. Barna, Z. and Kadar, M. (2012). The risk of contracting infectious diseases in Public. Medical Research Journal (4): 215-612.
5. Barrell, R. A. E., Hunter, P. R. and Nichols, G. (2000). Microbiological standards for water and their relationship to health risk. *Commun. Dis. Public Health*, (3): 813.
6. Bilajac, L., Lusic, D. V., Jelinic, D. J. and Ruvarina, T. (2012). Microbiological and chemical indicators of water quality in indoor hotel swimming pools before and after training of swimming pool operators. *Journal of Water and Health*, 10: 108-115.
7. Borchardt, J. A. and Walton, G. (1971). Water quality and treatment: A handbook of public water supply. *American Water Works Association*, 1-52.
8. Bushon, R. N. and Francy, D. S. (2003). Protozoan pathogens: National Field Manual for the Collection of Water-Quality Data. U.S. *Geological Survey Techniques of Water. Resources Investigations.* Book 9-A7 (third edition), 3-10.
9. Cairncross, S. C., Curtis, D. G., Feahem, R. L. and Bradley, G. H. (2000). Evaluation for village water supply planning. Chichester: *John Wiley and Sons*, 55-220.
10. Cairns J. J. and Dickson, K. L. (2003). Biological methods for the assessment of water quality. *American Water Works Association Bulletin*, 5-13.
11. Centre for Environmental Health (2005). Coliform bacteria in drinking water supplies. New York State Department of Health, 1-800-4 5 8 - 1 1 5 8 e x t. 2 - 7 6 5 0 orbpwsp@health.state.ny.us.
12. Chapra, S. C. (1997). Surface Water-Quality Modeling. McGraw- Hill Series in Water Resources and Environmental.
13. Chapman, D. (1996). Water quality assessment, a guide to the use of biota, sediment and water in environmental monitoring, Second edition, Publication by E & FN Spon, Printed by University Press, Cambridge, UK. ISBN 0419215905 (HB).
14. Clarke, E. O., Anetekhai, M. A., Akin-Oriola, G. A., Onanuga, A. I. S., Olaninmoye, O. M., Adaboyejo, O. A. and Agboola, I. (2004). The Diatom (Bacillariophyta) diversity of an open access lagoon in Lagos, Nigeria. *Journal Research and Review in Science*, 3: 70-77.
15. Cruickshank, R., Duguid, J. P., Marmion, B. P. and Swain, R. H. A. (1975). Medical microbiology: A guide to laboratory diagnosis and control of infections. 12th ed. Vol 1. Edinburgh. Churchhill Livingstone, 585.
16. Dharmappa, H. B., Wingroove, K., Sivakuma, M. and Singh, R. (2000). Wastewater and Strom water minimization in a cool mine. *Journal of Cleaner Production*, 8: 2334.
17. Edberg, S. C., Rice. E. W., Karlin, R. J. and Aden, M. J. (2000). Escherichia coli: The best biological drinking water indicator for Public Health Protection. *Journal of Applied Microbiology*, 88: 106 -11.
18. Edimeh, P. O., Eneji, I. S., Oketunde, O. F. and Sha'ato, R. (2011). Physicochemical parameters and some Heavy metals content of Rivers Inachalo and Niger in Idah, Kogi State. *Journal Chemical Society Nigeria*, 36(1): 95-101.
19. Environmental Protection Agency (EPA) (2004). Guidelines for Water Reuse. 625/R- 04/108. Environmental *Protection Agency*. Washington, D.C. U.S.
20. Eric, D., and Catherine, A. M. (1997). Respiration and critical case medicine, 59:162- 172.http:/ /green .atsjournals.org/cgi/content /fully/158/11/166).
21. Evans, J. (2007). Except from Total Swimming. Pp 224 ISBN 13:9780736068482 http://www.humankinetics.com/products/all-products/janet-evans-total-swimming.
22. Fair, G. M., Gerger, J. C. and Okun, D. A. (2001). Water purification and waste water treatment disposal. New York: John Wiley and Sons, 31-192.
23. Farthing, M. J. G., (2000). Clinical aspects of human cryptosporidiosis. In: Petry, F. (Ed.), Cryptosporidiosis and Microsporidiosis, Contrib. *Microbiology*, 6: 50–74.
24. Fritz, C. (2001). Watershed Information Network: A Watershed Report and Suggested Framework for

Integrating Water Quality Monitoring Efforts, 10-24.
25. Grigoryan L, Burgerhof JG, Haaijer-Ruskamp FM, et al. (2007). Is self-medication with antibiotics in Europe driven by prescribed use? J. Antimicrob. Chemother, 59: 152-156.
26. Isaak, R. A. and Morris, J. (1980).Rates of transfer of active chlorine between nitrogenous substrates. In: Jolly Rl, ed. Water chlorination. Vol.3. Ann Arbor, Ml, Ann Arbor Science Publishers.
27. Itah, A. Y., Etukudo, S. M. and Akpan, E. J. (1996). Bacteriological and chemical analysis of some rural water supplies in Calabar, Nigeria. *West Africa Journal Biology of Applied Chemistry*, 41: 1-10.
28. Kuzgunkaya, E. and Yildirim, N. (2010). Pre-Feasibility Study of a Swimming Pool Complex for a University Campus. A report for Proceedings World Geothermal Congress 2010: Bali, Indonesia, 1-7.
29. Lamb, J. C. (1985). Water Quality and its control, John Wiley and Sons, New York, 131.
30. Leoni, E., Legnani, P., Buccisabattini, M. A. and Righi, F. (2001). Prevalence of Legionella species in swimming pool environment. Pergamon, 35(15): 3749– 3753.
31. Leoni, E., Legnani, P., Mucci, M. T. and Pirani, R. (1999). Prevalence of Mycobacteria in a swimming pool environment. Microbiology, 87: 683–688.
32. Levy SB. (1998). The challenge of antibiotic resistance.http://schimizzi.cmswiki.wikispaces.net/file/view/antibiotic%20resistance.pdf/493751958/antbiotic%20resistance.pdf Scientific American, 278: 32 – 39.
33. Luebbers, M. (2012). Just Swimming the Best Way to Lose Weight.
34. Mackereth, F. H., Heron, J. and Talling, J. F. (2003). Water analysis. Ambleside: *Fresh Water Biological Association Scientific Publication*, 43-69.
35. Marshall, J. W. and Winterbourn, I. M. J. (1979). An Ecological study of a small New Zealand stream with particular reference to the Oligochaeta. Hydrobiology, 65:199-208.
36. Okafor, N. (1985). Aquatic and waste microbiology.1st ed. Fourth Dimension publishing Company Ltd Enugu Nigeria Pp.187-219 ISBN 9781561270.
37. Sule, I. O., Agbabiaka, T. O., Saliu, B. K. and Oyerinde, E. O. (2010). Physicochemical and Bacteriological Assessment of some Swimming Pools within Ilorin Metropolis, Kwara of Nigeria. Biological and Environmental Sciences. *Journal for the Tropics*, 7(4): 108–11.
38. Sule, I. O., and Oyeyiola, G. P. (2010). Bacteriological Assessment of some Swimming Pools within Ilorin Metropolis, Kwara of Nigeria. *Bioresearch Bulletin*, 1: 29-33.
39. Thickett, K. M., Mccoach, J. S., Gerber, J. M. and Burge, P.S. (2002). Occupational asthma caused by chloramines in indoor swimming-pool air. *European Respiratory Journal*, 19: 827-832.
40. United Nation Development Programme (UNDP) (2004). Water as a source of sickness. United Nation Development Programme Source: a short guide, 1: 11-13.
41. Walakira, P. (2011). Impact of industrial Effluents on Water Quality of Receiving Streams in Nakawa-Ntinda, Msc. Thesis, Makerere University. Uganda. *Journal of Applied Science and Environmental Management*, 15(2): 289-296.
42. World Health Organization (WHO) (2006). Guidelines for Safe Recreational Water Environments Volume 2: Swimming Pools and Similar Environments. World Health Organization, Geneva, Switzerland.
43. World Health Organization (WHO) (2011). Guidelines for Drinking water Quality, 4th ed. World Health Organization, Geneva, Switzerland.