Original Research Article

Assessment of the Physicochemical and Bacteriological Quality of Swimming Pool Water in Some Hotels in Ado-Ekiti, Nigeria

ABSTRACT

The physicochemical and bacteriological assessment of some hotel swimming pools in Ado-Ekiti, Nigeria was investigated to determine possible risks of infections to swimmers. Five swimming pools were studied with samples collected before and after swimming from two different sections in each of the pool. The average pH of the pool water ranged from 6.76 - 7.13. Pool water temperatures varied over a narrow range of 23.0 to 27.50 °c. With regards to microbial contamination, coliform counts were generally high in the pool waters after swimming, relative to their respective levels before swimming. *Escherichia coli* and *Enterococcus faecalis* were detected in all the five swimming pools while *pseudomonas aeruginosa* was detected in only two of the swimming pools. Some of these isolated bacteria showed resistance to selected antibiotics. The results revealed that the swimming pools have not met the World Health Organization (WHO) standard for recreational waters. The swimming pools may pose a serious public health hazard, hence, the need for an effective and urgent intervention while there is need for constant monitoring of recreational facility to safeguard the health of the pool users.

1. INTRODUCTION

Swimming pool is a confined body of water that is mainly for swimming and aquatic recreation. It is a body of water of limited size contained in a holding structure, could be concrete tanks, large paved holes or large artificial basins containing water for swimming. Hotel swimming pool is one of the recreational facilities being visited by residents of Ado-Ekiti for pleasure or leisure. Public swimming pools are increasingly used worldwide for the purpose of recreation, sport and rehabilitative treatment (4).

However, there are diverse kinds of microorganisms that can be found in swimming pools, they may be introduced into the pool water in so many ways, through the pollution by pathogenic micro-organisms from infected swimmers, via skin secretion, mouth sources such as (saliva, mucus, vomit), urine, and nose. Also, through accidental release of faeces, or by contaminated objects and clothes, airborne contamination, incoming water from unhygienic source, and bird droppings (11). These pathogenic organisms found in swimming pools and other recreational water bodies includes bacteria, virus, fungi, and parasites (12, 14). Swimming pools have been known to be associated with the outbreaks of waterborne infections (21, 5). The pathogens found in the pool can cause digestive system infection, eyes and ear infection, infections of the upper respiratory tract, systemic infection and skin diseases in swimmers, especially for immunocompromised persons. Many times, the risk of illness or infection is associated to faecal contamination of the water as a result of the excreta released by swimmers, direct animal contamination can also make outdoor pools unsafe. Pathogenic organisms are being introduced into the swimming pool through non-faecal human source including vomit, saliva, mucus or skin (8).

Although, the sanitary condition in swimming pool is scanty and some of the pools have inadequate water quality monitoring units. Sanitation methods including filtration in order to remove pollutants, disinfection

33   to kill infectious microorganisms, promotion of hygiene by swimmers to reduce the risk of introducing
34   contaminants into the swimming pool water, as well as regular analysis of pool water, checking for
35   chlorine and pH levels is essential (8).
36

37   Ordinarily, the water for swimming is supposed to meet the same standard as portable water by being
38   transparent, odourless, and tasteless having a freezing and boiling point of 0° and 100° respectively. It
39   must also be free from pathogenic contaminants. With the use of disinfectants and regular change of the
40   water, the portability of the swimming pool water can be improved (22). Chemicals are globally used by
41   most hotels to sanitize the pool water. Liquid form of chlorine, sodium hypochlorite or calcium
42   hypochlorite solution are used by some hotels. Though, some of these Swimming pool operators prefers
43   iodine to chlorine since it is a disinfectant whose action is less hindered by organic matter and having
44   lesser risk of eye and skin irritation than chlorine. There is also the recommendation of bromine (22).
45

46   Viable microorganisms should be absent in a properly managed and disinfected pool water. A re-
47   circulating system in which water is effectively filtered and disinfected is now present in modern swimming
48   pools. Although, researches have shown that hi-tech systems or disinfectant cannot hinder the
49   colonization of the pool water with hazardous pathogens (10, 2).
50

51   Therefore, this study aimed at assessing the physicochemical and microbiological quality of swimming
52   pools in selected hotel swimming pool in Ado-Ekiti metropolis, Nigeria. Also, to check for the antimicrobial
53   susceptibility of the isolated bacteria from the pools and relate the findings to hygiene, pool maintenance
54   and possible implication on public health.
55

56 2. MATERIAL AND METHODS
57

58 2.1 Sources and collection of samples
59   Water samples were aseptically collected from 5 different hotel swimming pools in Ado-Ekiti Metropolis,
60   Nigeria using the techniques of Cruickshank et al., (15) and Okafor (19). All swimming pools are
61   constructed with glazed tile and are of varying shapes (irregular, square, circular, rectangular and oval)
62   while their sizes ranged from 50 to 1500 m^2. The sampling periods were in the morning before swimming
63   takes place, and evening after swimming.
64

65 2.2 Physicochemical Assessment
66   The physico-chemical properties examined included pH, temperature, total dissolved solid (TDS), Total
67   hardness, nitrate, chlorides, turbidity, conductivity, calcium hardness, magnesium hardness, and total
68   dissolved solid. The conductivity, pH and temperature were determined in situ using portable digital
69   conductivity, pH meter (Beckman, Model 50) and thermometer respectively. The turbidity of the water
70   samples was determined by the turbidimetric method using a colorimeter (JENWAY, Model 6051). Ultra-
71   violet spectrometer was used for the determination of nitrate concentrations.
72
73

74 2.3 Microbiological Analyses
75   *Esherichia coli* count, Total Coliform Count (TCC) and Total Bacterial Count (TBC), were carried out using
76   Eosin methylene blue Agar (EMB), MacConkey agar and Nutrient agar (NA) respectively. However, pour
77   plate method was used, by pouring agar to sterile Petri-dishes containing 0.1 ml serially diluted swimming
78   pool water samples of 10^3 and 10^4 and the plates were incubated in inverted position aerobically at 28^0C
79   for 48 hours. The number of colonies between 40-300 were counted were counted after incubation.

2.4 Identification of Bacterial Isolates

The bacterial isolates were identified by morphological characteristics, Gram's reaction, motility test, catalase test, oxidase test, citrate, methyl red test, sugar fermentation and indole test.

2.5 Antibiotic Sensitivity Test of Bacterial Isolates

Susceptibility of the bacterial isolates to antibiotics was carried out with the use of Kirby Bauer disk diffusion method on Mueller-Hinton medium. The results were read and interpreted according to the guidelines of Clinical and Laboratory Standards Institute Guidelines (CLSI, 2012). The antibiotics tested were Tarivid, Ciproflox, Reflacine, Augmentin, Gentamycin, Streptomycin, Ceporex, Nalidix A-C, Septrin, Ampicillin, pefloxacin, Gentamycin, Ampiclox, Zinnacef, Amoxicillin, Rocephine, Ciprofloxacin, Streptomycin, Erythromycin

3. RESULTS AND DISCUSSION

3.1 RESULTS

The bacteriological assessment of swimming pool water samples obtained from five (5) different hotels in Ado-Ekiti, Nigeria was carried out before and after swimming. The Total Bacteria Count (TBC), Total Coliform Counts (TCC) and *Escherichia coli* Count was enumerated. Also, the physicochemical analysis of the swimming pool water samples was obtained. The bacteria isolates were further evaluated for antibiotic susceptibility.

Table 1. Physicochemical Analysis of Swimming Pool Water

Parameters	Pool A		Pool B		Pool C		Pool D		Pool E		Average		WHO and EPA Permissible Limit
	BU	AU	BU	AU	BU	BU	AU	AU	BU	AU	BU	AU	
Transparency	Clear		Clear		Clear		Clear		Clear				
Colour	Colourless		Colourless		Colourless		Colourless		Colourless				
Turbidity (NTU)	4.5	5.5	5.5	6.5	4.5	5	5.5	6.5	4.5	5.5	4.9	5.6	5 NTU
Temperature (^{0}C)	23.5	25	25.5	27.5	23.5	26	25.5	26.5	23	25.5	24.2	26.1	26^0C
Ph	6.99	7.03	6.56	7.08	6.95	7.2	6.57	7.23	6.71	7.12	6.76	7.13	8.50
Chlorine (mg/L)	1	0.8	1.8	1	0.9	0.7	1.6	0.9	0.9	0.7	1.24	0.82	3 (mg/L)
Nitrate (mg/L)	2.4	3.2	3.5	4.8	3.1	3.5	3.5	4.5	3.6	4.2	3.22	4.04	5 (mg/L)
Conductivity (µs/cm)	40	44	43	56	80	88	266	298	130	146	111.8	126.4	250.00 (µs/cm)
Total Hardness (mg/L)	52	74	78	98	80	93	89	100	95	112	78.8	95.4	150 (mg/L)
Calcium Hardness (mg/L)	32	43	45	46	42	56	52	75	58	68	45.8	57.6	150 (mg/L)

Magnesium Hardness (mg/L)	20	31	33	54	38	43	37	25	37	54	33	42.2	150 (mg/L)
Total Dissolved Solids (mg/L)	**340**	**394**	**562**	**764**	**452**	**553**	**798**	**896**	**435**	**654**	**517.4**	**655.2**	**500 (mg/L)**

104 Key: BU = Before use   AU = After use Pool A- Delight hotel, Pool B- Prosperous hotel, Pool C-
105 Pathfinder hotel, Pool D- Midas Hotel Pool E- KSSD Hotel
106
107 **Table 2. Total Bacteria Count (TBC)**
108

Sample Site	Before use		After use (cfu/ml)	
	10^3	10^4	10^3	10^4
Pool A	90	85	155	112
Pool B	0	0	82	50
Pool C	74	71	128	122
Pool D	76	62	92	85
Pool E	95	52	157	102
Mean	67.0	54.0	122.8	94.2

109
110 Key: Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel Pool E-
111 Delight Hotel
112
113 **Table 3.   Total Coliform Count (TCC)**
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Sample Site	Before use		After use (cfu/ml)	
	10^3	10^4	10^3	10^4
Pathfinder Hotel	112	100	170	129
Prosperous Hotel	0	0	129	104
Midas Hotel	66	59	96	75
KSSD Hotel	94	70	99	94
Delight Hotel	68	72	68	104
Mean	68.0	60.2	112.4	101.2

115 Key: Pool A- Pathfinder Hotel Pool B- Prosperous Hotel Pool C- Midas Hotel Pool D- KSSD Hotel Pool E-
116 Delight Hotel
117
118 **Table 4.   *Escherichia Coli* Count**

Sample Site	Before use		After use	(cfu/ml)
	10^3	10^4	10^3	10^4
Pool A	93	63	104	59
Pool B	0	0	63	81
Pool C	73	61	80	62
Pool D	90	57	103	93
Pool E	40	41	81	58
Mean	59.2	44.4	86.2	70.6

Table 5. Antibiotic Sensitivity of Gram-Positive Bacteria

		Antibiotics									
Sample	Bacteria isolated	P*efloxacin	Gentamycin	Ampiclox	Zinnacef	Amoxacin	Recephine	Ciprofloxacin	Streptomycin	Septrin	Erythromycin
MS BU 1	*E. faecalis*	R	I	I	I	I	I	I	R	R	I
PAT AU 1	*E. faecalis*	S	I	S	S	I	S	R	S	I	I
PRO AU 3	*E. faecalis*	I	I	I	I	I	R	I	R	I	R
DEL BU 2	*E. faecalis*	1	S	I	I	S	I	S	I	S	S
KSD AU 1	*E. faecalis*	R	R	R	R	R	I	R	R	I	R

Key: S- susceptible; R- Resistant; I- Intermediate; MS- Midas; BU- Before Use; PAT- Pathfinder; AU- After Use; PRO - Prosperous; DEL- Delight; KSD- KSSD

Table 6. Antibiotic Sensitivity Reaction of Gram-Negative Bacteria

		Antibiotics									
Sample	Bacteria isolated	Tarivid	Reflacine	Ciproflox	Augmetin	Gentamycin	Streptomycin	Ceporex	Nalidix A.C	Septrin	Amplicilin
MS BU 2	*Escherichia coli*	I	I	R	R	S	I	I	I	I	I
MS AU 1	*Escherichia coli*	S	R	R	I	I	I	I	R	R	I
MS AU 2	*Escherichia coli*	I	R	I	I	I	S	I	I	I	I
MS AU 3	*Escherichia coli*	I	I	R	I	I	I	I	I	I	I
PAT BU 1	*Escherichia coli*	S	I	R	R	I	I	I	R	I	I
PAT BU 2	*Escherichia coli*	R	S	I	I	I	I	I	I	I	I
PAT AU 1	*P. aeruginosa*	I	I	I	I	I	I	I	R	I	R
PAT AU 3	*Escherichia coli*	I	I	I	I	I	S	I	I	I	S
PRO BU 1	*Escherichia coli*	I	I	I	I	I	I	I	I	I	S
PRO BU 2	*Escherichia coli*	I	I	I	S	I	S	S	I	I	I
PRO AU 1	*P. aeruginosa*	R	I	I	I	I	R	I	I	I	I
DEL BU 1	*Escherichia coli*	R	R	I	I	R	R	I	I	I	I
DEL AU 1	*Escherichia coli*	I	I	I	R	I	I	I	I	I	I
KSD BU 1	*Escherichia coli*	I	I	S	I	I	I	I	S	S	I
KSD BU 2	*Escherichia coli*	I	I	I	I	I	S	I	I	I	I

KSD AU 2	*Escherichia coli*	R	I	I	I	I	R	R	I	I	I

130 S- susceptible; R- Resistant; I- Intermediate; MS- Midas; BU- Before Use; PAT- Pathfinder; AU- After
131 Use; PRO - Prosperous; DEL- Delight; KSD- KSSD

3.2. DISCUSSION

134 There are a lot of contrary opinion as to how the quality of swimming pool water can be assessed. Some
135 researchers opined that microbes which are indicators of good hygiene such as heterotrophic bacteria
136 and total coliform should be looked out for, while others consider those of faecal pollution to be the best,
137 since infection risk is more related to microbes associated with the mouth, skin, and upper respiratory
138 tract of swimmers other than faecal contamination(18). However, there is no much assurance that
139 microbes can give a reliable prediction regarding the risks of swimming to public health (32, 16, 18, 17,
140 20).

142 The average pH values recorded in all the five swimming pools ranging from 6.56-7.23 before and after
143 use were all within WHO and EPA permissible limit. The pH of water is an essential parameter in
144 swimming pools since it necessary for the effective disinfection and coagulation, it also prevents pool
145 fabric from destruction in order to safeguard the users (30).

147 The chlorine level detected in all the studied swimming pool was between 0.7-1.24 and within the WHO
148 (9) permissible limit. The low residual chlorine level in the pool could be due to high presence of bacteria
149 or inadequate chlorination. chloride detection in water implies its effectiveness as a disinfecting agent and
150 an indication that the swimming pool water is properly sanitized (3). All the analysed swimming pool water
151 were colourless. Although, human activities, peat, plankton, vegetation and natural metallic ions are
152 responsible for change in the colour of water.

154 The values of total dissolved solids (TDS) recorded before and after swimming were within the acceptable
155 range of 500 mg/l recommended by WHO for drinking water. However, before swimming, the value was
156 generally lower than after swimming, this may be due to the presence of inorganic salts and other
157 dissolved materials in the pool (3). The values obtained is similar to that reported by Aremu *et al.,* (27).
158 The turbidity values observed before swimming were lower than after swimming except Prosperous and
159 Midas Hotel which recorded values of 5.5 respectively, above the WHO (31) guideline of 5 NTU for
160 drinking water. This may be as a result of the discharged colloidal and organic matter from bathers during
161 swimming, it is not impossible that most of the swimmers do not shower before swimming.

163 John Girvan deduced that nitrate in the pool can cause the presence of algae and other contaminants
164 that may not respond to normal treatment. However, some other pool techs opined that nitrates in pool
165 lock up chlorines and could drastically increase the consumption of sanitizer (3).

167 The temperature values obtained before swimming were within the recommended limit of WHO (31)
168 which is 22^0C - 26^0C. This is similar to the results of Edimeh et al. (25), Clarke et al. (24). While the
169 values reported after swimming were generally high with Prosperous Hotel recording the highest value of
170 27.5^0C which was slightly above the WHO (31) guidelines of 22^0C - 26^0C. The values of temperature
171 obtained in this research is dissimilar to that of Onifade et al., (1) who recorded temperature greater than
172 26^0C. The high values of temperature observed could be attributed to the various body temperature of the
173 swimmer. The weather also affects the temperature considering the different sampling times of the pools
174 (28). The increase in temperature of the swimming pool aids the growth of bacteria (7).

176 The bacteriological analysis of the analysed swimming pools water showed the extent to which the water
177 was contaminated by various microorganisms, since *Esherichia coli, Enterococcus faecalis and*

178 *Pseudomonas aeruginosa* were isolated. The isolation of significant numbers of bacteria from swimming
179 pools is an evident indication that it is either the source of raw water doesn't have enough protection or
180 deficiency in the treatment of the pool water (35). Although, the bacteriological limits for swimming pools
181 varies per country compared to that of drinking waters which are according to international agreement by
182 stakeholders. For instance, it is recommended in the United Kingdom that pool water should not have any
183 coliform microbe in 100ml of water (6).

185 The mean total bacterial counts (TBC) for all the pool water before and after swimming were generally
186 high and exceeded the EPA and WHO permissible limit for water. The high total bacteria count indicates
187 that organic and dissolved salts may be highly present in the water. Mostly, animal and human wastes
188 are the primary sources of these bacteria in water. Other sources of bacterial contamination are surface
189 runoff, pasture, and other land areas where animal wastes are deposited. Discharge from septic tanks,
190 seepage or sewage treatment facilities and natural soil or plant bacteria can also contaminate water (36).

192 Some of the pools considered in the study recorded high levels of *Escherichia coli* and this do not
193 conform with the recommended standard of WHO for swimming pools. According to Edberg *et al.,* (26),
194 water sample from swimming pools should be devoid of any organism, not even coliforms in a 100 ml of
195 water because most swimmers get to swallow some of the pool water when swimming. *E. coli* being
196 present in swimming pool is as a result of poor pool management, lack of compliance to safeguarding
197 measures of the source of water and insufficient disinfection of the pool (34). The result of this research is
198 similar to that of Bello *et al.,* (22) who also isolated *Escherichia coli, Pseudomonas aeruginosa,*
199 *Enteroccocus faecalis* from swimming pool.

201 The mean values of TBC and TCC before and after swimming were relatively high in four of the swimming
202 pools and above the recommended value of zero for WHO (31) guideline for drinking water. Indabawa *et*
203 *al.,* (33) similarly isolated coliforms in their research, Onifade et al (1) also isolated *Escherichia coli* from
204 water samples in Ado-Ekiti. The capabilities of Pathogenic microbes have been reported in large number
205 of bacteria species including *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia* and
206 *Staphylococcus aureus* (29).

208 The antimicrobial susceptibility test revealed that majority of the isolates have intermediate and high
209 resistant to most of the antibiotics that could be used in treating resulting infection. The implies that it will
210 be difficult to treat any infection gotten as a result of swimming in the contaminated pools. (13).
211 Opportunistic pathogen can also intensify the situation and therefore increase the health risks associated
212 with swimming on these contaminated pools (23). This study shows the need to do more investigation on
213 the prevalence of antibiotic susceptibility genes in the swimming pool water, as well as the distribution of
214 susceptible genes among the pathogenic bacteria.

4. CONCLUSION

219 The isolation of pathogenic bacteria from this study implies that there is poor sanitary maintenance of the
220 pool and improper hygienic practices by swimmers. Hence, the need to effectively monitor recreational
221 outfits such as hotel swimming pools by sensitizing everyone associated with the facility, improving pool
222 circulation and ensure the construction is done in such a way to prevent external contamination. By such
223 doing, there will be lesser risk posed on swimmers and bring about improvement in public health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Onifade OE, Faeji CO, Owoeye JA and Onipede T. (2018). Physicochemical and Bacteriological Assessment of Some Drinking Water Sources around Student Hostel in Ekiti State University, Ado-Ekiti. J. Chem. Bio. Phy. Sci. Sec. D; May 2018 – July-2018, Vol. 8, No.3; 172-184.

2. CDC. (2004). An outbreak of norovirus gastroenteritis at a swimming club – Vermont. Morbidity and Mortality Weekly Report 53, 793-795.

3. EPA. (2007). Environmental Protection Agency. Method 1680: Fecal coliforms in biosolids by multiple-tube fermentation procedures, Draft Document No. EPA 821-R-02-026.

4. Saberianpour S, Momtaz H, Ghanbari F and Mahmodi F. (2015). Assessment of bacterial and fungal contamination in public swimming pools in Shahrekord, Iran. J. Trop. Dis. 4(2), 1-4.

5. Schets FM, Schijven JF and de Roda HAM. (2011). Exposure assessment for swimmers in bathing waters and swimming pools. Water Research 45, 2392-2400

6. Craun GF, Calderon RL and Crawn MF. (2005). Outbreaks associated with recreational water in the United States. Int. J. Environ. Health Res, 15(4), 243-262.

7. Leoni E, Legnani P, Buccisabattini MA, Righi F. Prevalence of legionella ssp. (2001). In swimming pool environment. Pergamon. 35(15):3749–3753

8. Papadopoulou C, Economou V, Sakkas H, Gousia P, Giannakopoulos X, Dontorou C and Filiossis G. (2008). Microbiological quality of indoor and outdoor swimming pools in Greece: Investigation of the antibiotic resistance of the bacterial isolates. Int. J. Hyg. Environ. Health 211, 385-397.

9. World Health Organization (2003). Guidelines for Safe Recreational Water (3rd edition). 3:1-120

10. Fiorillo L and Zucker M. (2004). Laboratory Manual of Microbiology, spectrum books limited, Ibadan, 127 pp.

11. Sule IO and Oyeyiola GP. (2010). Biological assessment of some swimming pools within Ilorin metropolis, Kwara of Nigeria. Bioresearch Bullentin,1:29-33.

12. Centers for Disease Control and Prevention (2009). Healthy housing reference manual, chapter 14: residential swimming pools and spas. CDC.gov. Department of Health and Human Services, pp.1-11.

13. Son R, Rusul G, Sahilah AM, Zainuri A, Raha AR and Salmah I. (1997). Antibiotics resistance and plasmid profile of Aeromonashydrophila isolates from cultured fish, Telapia. Letters in Applied Microbiology, 24:6.

14. Sohrabi Y, Tari K and Charganeh SS. (2016). Surveying hygiene indices of water of swimming pools in Kermanshah City (Iran), 2015. Research Journal of Medical Sciences, 10(4): 302-306.

15. Cruickshank R, Duguid JP, Marmion BP and Swain RHA. (1975): Medical microbiology: a guide to laboratory diagnosis and control of infections. 12th ed. Vol 1. Edinburgh: Churchhill Livingstone: 585pp.

16. Favero MS, Drake CH and Randall B. (2004): Use of staphylococci as indicator of swimming pool pollution. U.S. Public. Health Report. 79, 61 70.

17. Mossel DA. (2006). Microbiological markers for swimming associated infectious health hazards. American Journal of Public Health76, 297.

271 18. Seyfried PL, Tobin RS, Brown NE and Ness PF. (2005b) A prospective study of swimming-
272 related illness, Morbidity and the microbiological quality of water. American Journal of Public
273 Health 75, 1071 1074.
274 19. Okafor N. (1985): Aquatic and waste microbiology. Ibadan: Fourth Dimension Publishers, 198pp
275 20. Mood EW. (2007). Bacterial indicators of water quality in swimming pools and their role. In
276 Bacterial Indicators Health Hazards Associated with Water. ASTM STP635, pp. 239 246. Am.
277 Soc. Test. Mater., Philadelphia, Pa.
278 21. Dziuban EJ, Liang JL, Craun GF, Hill V, Yu PA, Painter J, Moore MR, Calderon RL, Roy SL,
279 Beach MJ. (2006). Surveillance for waterborne disease and outbreaks associated with
280 recreational water – United States, 2003–2004. MMWR, 55, 1-24.
281 22. Bello OO, Mabekoje OS, Egberongbe HO and Bello TK. (2012) Microbial Qualities of Swimming
282 Pools in Lagos, Nigeria. International Journal of Applied Science and Technology, 2, 89-96.
283 23. Critchley MM, Cromar NJ, McClure NC, Fallowfield HJ. (2003): The influence of the chemical
284 composition of drinking water on cuprosolvency by biofilm bacteria. *J ApplMicrobiol.*;94:501–507.
285 24. Clarke EO, Anetekhai MA, Akin-Oriola GA, Onanuga AIS, Olaninmoye OM, Adaboyejo OA and
286 Agboola I. (2004). The Diatom (Bacillariophyta) diversity of an open access lagoon in Lagos,
287 Nigeria. Journal Research and Review in Science. 3:70-77
288 25. Edimeh PO, Eneji IS, Oketunde OF and Sha'ato R. (2011). Physico-chemical parameters and
289 some Heavy metals content of Rivers Inachalo and Niger in Idah, Kogi State. Journal Chemical
290 Society Nigeria 36 (1): 95-101
291 26. Edberg SC, Rice EW, Karlin RJ and Aden MJ. (2000). Escherichia coli: The best biological
292 drinking water indicator for Public Health Protection Journal of Applied Microbiology, 88:106 -11
293 27. Aremu MO, Olaofe, Ikokoh PP and Yakubu MM. (2011). Physicochemical characteristics of
294 stream, well and borehole water sources in Eggon, Nasarawa State, Nigeria. Journal of Chemical
295 Society of Nigeria; 36 (1): 131-136
296 28. Fritz C. (2001). Watershed Information Network: A Watershed Report and Suggested Framework
297 for Integrating Water Quality Monitoring Efforts. Pp. 10 -2400
298 29. Gilbert P, Evans DJ, Brown MRW. (2002). Formation and dispersal of bacterial biofilms in vivo
299 and in situ. J. Appl. Bacteriol. Symposium Supplement, 74:67S– 78S.
300 30. Thickett KM, Mccoach JS, Gerber JM and Burge PS. (2002). Occupational asthma caused by
301 chloramines in indoor swimming-pool air. European Respiratory Journal, 19:827-832
302 31. World Health Organization (WHO) [2011] Guidelines for Drinking water Quality, 4th ed. World
303 Health Organization, Geneva, Switzerland.
304 32. Galbraith NS (2000). Infections associated with swimming pools. *Environmental Health* 15:31-33.
305 33. Indabawa II, Ali S and Mukhtar MD. Assessment of Microbiological and Physico-Chemical Quality
306 of Some Swimming Pools within Kano Metropolis, Kano Nigeria. 3rd International Conference on
307 Biological, Chemical & Environmental Sciences (BCES-2015) Sept. 21-22, 2015 Kuala Lumpur
308 (Malaysia)
309 34. Barrell RAE, Hunter PR and Nichols G (2000). Microbiological standards for water and their
310 relationship to health risk. Commun Dis Public Health; (3): 813
311 35. Borchardt JA and Walton G. (1971). Water quality and treatment: A handbook of public water
312 supply. American Water Works Association. 1-52. Retrieved from http://www.ijastnet.com/journals
313 / Vol_2_No_8_October_2012/11.pdf [Accessed December 12, 2014]
314 36. Howe AD, Forster S, Morton S, Marshall R, Osborn KS, Wright P, Hunter PR. (2002)
315 *Cryptosporidium* oocysts in a water supply associated with a cryptosporidiosis outbreak. Emerg
316 Infect Dis. 2002;4(6):619–624