Assessment of Microbiological and Physico-Chemical Quality of Some Swimming Pools within Kano Metropolis, Kano Nigeria

*[1]Indabawa I.I., Ali S.[2] and M.D Mukhtar[3]

Abstract—Physico-chemical and Microbiological qualities of Five swimming pools located within kano metropolis were carried out. The results obtained showed that the temperature ranged between 24.5 ^{o}C – 27.5 ^{o}C and 25.0 - 28.5^{o}C before and after use, chloride content ranged between 0.08 -2.0 mg/l and 002 – 1.0 mg/l before and after use respectively. Aerobic mean bacterial counts ranged between < 1.0 x 10^{1} – 2.8 x 10^{6} CFU/ML before use and < 1.0 x 10^{1} - 4.30 x 10^{7} CFU/ML after use, anaerobic mean counts ranged between< 1.0 x 10^{1} - 1.2 x 10^{3} CFU/ML and < 1.0 x 10^{1} CFU/ML – 1.6 X 10^{4} CFU/ML before and after use respectively, the mean values of coliforms was 1 – 11 MPN/ML and 1 – 49 MPN/ML before and after use. The dominant bacterial contaminants isolated were *E. aerogenes, S. aureus, K. pneumonia, E. coli* and *C. perfringes.* Fungal contaminants isolated were Yeast species and Mold species and *Aspergillus fumigatus.* The result of this study therefore showed that the swimming pools were aesthetically unsuitable for recreational purposes. Efforts to enforce effective pool water treatment by the proprietors are recommended.

Keywords—Swimming pool, Bacteriological, physico-chemical

I. Introduction

IN Kano metropolitan, swimming pools is one of the recreational facilities patronized by different classes of people for leisure or pleasure in most of the hotels or guest houses. However, the swimming pools may harbor pathogenic micro-organisms from infected swimmers or from contaminated water source or from airborne contamination or from an ineffective treatment of the swimming pools [1]. These may leads to contracting of disease both superficial or systemic body parts which the swimmers or bathers may not be aware. Consequently the numbers of swimming pools are on the increase and information on their sanitary condition is scanty and water quality monitoring units are lacking in most of these pools.

A swimming pool is a body of water of limited size contained in a holding structure. It is also an artificially enclosed body of water intended for swimming and water based recreation. This water is generally of portable quality and is treated with additional disinfectants (chlorine compound and ozone). Although modern swimming pools have recirculation system so that the water can be filtered or disinfected effectively, relevant research studies shows that neither hi-tech systems nor disinfectant can prevent the colonization of the pool water with hazardous pathogens [2; 3] Bathing and swimming for pleasure has been practiced by many land animals for unrecorded ages and human record of the pleasure of immersion in water go back several thousand years ago [4]. The swimming pool water should meet potable water standard by being transparent, odorless and tasteless liquid having a freezing point of 0^{0}C and boiling point of 100^{0}C. It must also be free from contaminants (pathogenic bacteria, and fungi, algae, viruses and protozoan etc.)

A variety of microorganisms can be found in swimming pools which may be introduced in the pool in a variety number of ways. In many cases the risk of illness or infection has been linked to faecal contamination of the water due to faeces released by bathers or contaminated water source or may be as a result of direct animal contamination (E.g birds or rodents) [5; 6] The portability of swimming pool water is enhanced by frequently changing the water and the use of sanitation is to prevent the spread of diseases and pathogens between users.

II. Aim And Objectives Of The Research

The research was aimed to ascertain the physico-chemical and microbiological quality of some swimming pools in Kano metropolis so as to bring into light to reduce the risks of contracting disease in order to stem the incidence of recreational disease. The objectives include: determination of physico-chemical parameters (Temperature, pH, turbidity, chloride, phosphate, and nitrate. Dissolved oxygen etc), bacterial and fungal load, chloride contents before and after use.

III. Materials And Methods

Five outdoor swimming pools viz a viz Prince hotel (site A), Central hotel (site B), Royal Tropicana hotel (site C). Ni'ima Guest palace (site D), and Tahir Guest palace (site E) all located in Kano metropolis were selected during the summer season to assess their physicochemical and microbiological qualities Figure 1.0 water was collected aseptically from each swimming pool monthly, using dark brown and sterilized glass-stopper sampling bottles for a period of six months (February 2012 to July 2012). The samples were tested for Temperature, colour, conductivity, Total hardness, total dissolved solids (TDS), Ph, turbidity, chloride, nitrates,

Indabawa I.I. is with the Department of Plant Biology, Bayero University, kano Nigeria

Ali S. is with the Department of Microbiology, Bayero University, Kano Nigeria

M.D. Mukhtar is with the Department of Microbiology, Bayero University, Kano Nigeria

phosphate ion concentrations, Dissolved oxygen and Biological oxygen concentrations as described by [7; 8; 9; 10]. Enumeration of aerobic and anaerobic mesophillic bacterial counts, coliforms bacteria were carried out as described by [11; 12].

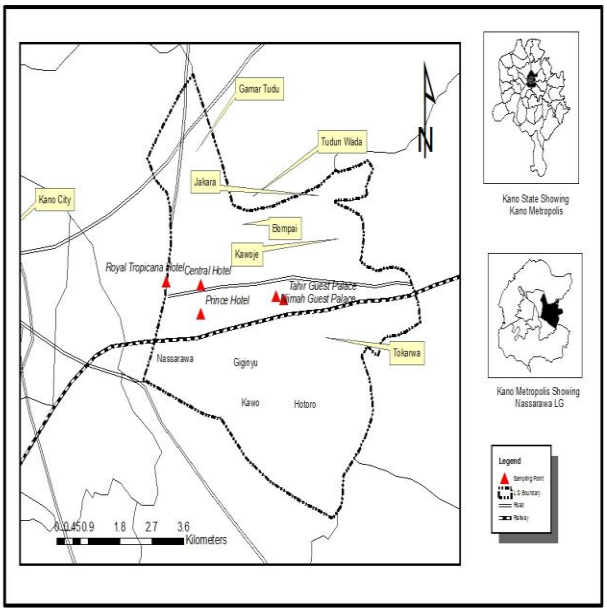

Fig. 1: Locations of studied swimming pools in Kano metropolis

IV. Results

A. Physico-Chemical Parameters of the Swimming Pools

The table 1 shows the physic-chemical parameters of water samples from the Five study sites. The turbidity values of all the swimming pools studied were within the range of 0 to 6 NTU as recommended by WHO and EPA standard except in site D which was above. The temperature of pools water ranges from 245-27.50C and 25.0-28.50C before and after use respectively in all the sites examined. The highest temperature (28.50C) was obtained at the same site D. The pH range was also 6.9-7.5 before and 7.1-8.9 after use falls within the acceptable standard of WHO and EPA.

The chloride content in some of the swimming pools are well treated with the acceptable dose (i.e 2.0, 1.0, 0.9) in site A, B and C before use and 1.0, 0.9, 0.8 after use respectively. Except in site D and E had the lowest dose recommended. These same sites also had the high levels of nitrate and phosphate as specified by WHO and EPA for recreational water. However the dissolved oxygen found to be below standard with increases in the BOD (Biological oxygen Demand) in site D and slightly in site E. moreover the percentage salinity of some of the pools water examined were 80-100% salinity while some pools fall within 30-10% salinity.

B. Bacteriological Quality of the Pools

Table 2.0 indicated the result of bacterial count in all the pools water investigated, in which the viable bacterial count of the pools water before use was found to be less than 1.0×10^1 to 2.80×10^6 cfu/ml before use and less than $1.0X10^1$ to $4.30X10^7$ cfu/ml after use. The anaerobic bacterial count was also less than $1.0x10^1$ cfu/ml to $1.2x10^3$cfu/ml before use (i.e after treatment) and less than $1.0x10^1$ to $1.6x10^4$cfu/ml after use.

C. Coliform Count

Table 3 showed the mean values of total coliforms which indicated coliforms 1 and 11 in site A and site D before and after use respectively.

Table 4 showed the mean values of total coliforms which indicated coliforms 1 and 49 in site A and site D before use and after use respectively.

Table 5 indicated faecal coliform count of 0.0 to 4.01 and 0.0 to 6.02 before and after use respectively.

Table 7 showed the occurrence of bacterial species in all the pools water analyzed in which most if the species isolated were found in site D and E while none has been seen in site A and B.

D. Fungal counts

The fungi isolated from swimming pools included *yeast* species, *mold* species and *Aspergillus fumigatus*. Results asserted that swimming pools site D and E have high rate of occurrence of fungi with 61% and 39% respectively. In totally, 61 colonies were isolated from five swimming pools. 37 colonies belongs to site D and 24 colonies belongs to site E. whereas site A, B and C have O colony respectively. Table 9 showed that colonial and morphological characteristics of the fungi isolates in which *mold* species is 43%, yeast 21% and *Aspergillus* fumigatus 34% that was isolated from environmental surfaces. Finding indicated that no dermatophyte were recovered from water samples, indeed the fungi isolated from water samples were common saprophytic flora and their presence in swimming pools were not important.

E. Results of Statistical Analysis

The result of the statistical analysis obtained showed a significance differences between the two means of observation/measurement before and after use by bathers.

t-test revealed significant difference in terms of mesophillic bacterial counts in the swimming pools before and after use ($P \leq 0.05$)

The computed value of t is large them the critical value of T-distribution i.e. 2.571. Thus, 9.084>2.571. Thus reject the null hypothesis and concluded that there is a significance difference in the effectiveness of treatment of the pools water before and after use.

TABLE I
PHYSICOCHEMICAL PARAMETERS OF WATER SAMPLES IN SOME SWIMMING POOLS IN KANO

Parameters	Site A		Site B		Site C		Site D		Site E		WHO and EPA standard for Recreational waters
	BU	AU	BU	AU	BU	AU	BU	AU	BU	AU	
Transparency	Very clear		Very clear		Clear		Slightly Cloudy		Slight cloudy		
Colour	Colourless		Colourless		Colourless		Colourless		Colourless		
Turbidity	0.0	1.0	1.0	1.5	1.52	2.0	6.5	7.5	4.5	5.5	6.0
Temperature ^{0}C	24.5	25.0	25.0	25.0	250	26.0	27.5	28.5	25.5	26.0	22-26^{0}c
pH	7.0	7.6	7.1	7.4	6.9	7.2	7.5	8.9	7.0	7.1	7.0 – 7.8
Chloride mg/l	2.0	1.0	1.0	0.9	0.9	0.8	0.05	0.02	0.08	0.05	1 – 3mg/l
Nitrate mg/l	2.8	3.0	2.6	4.6	5.0	6.5	8.6	13.3	6.6	10.6	1 – 5mg/l
Phosphate mg/l	0.5	2.2	2.3	3.6	3.8	4.6	9.6	12.6	6.9	9.2	1 – 10mg/l
Conductivity mg/l	40	44	43	56	80	88	266	298	130	146	1000µs/cm
Total Hardness	32	40	45	52	62	126	126	180	82	163	150mg/l
Total Dissolved Solid mg/l	200	260	363	452	1100	1200	2300	2800	1300	1500	500mg/l
Dissolved Oxygen mg/l	9.0	9.8	9.1	9.5	6.8	6.0	3.0	2.3	5.1	4.2	9 – 10mg/l
Biological Oxygen Demand	2.0	1.0	2.0	1.0	3.0	2.0	50.0	36.0	40.0	30.0	1 – 2
Salinity %	100		100		80		10		30		

Keys: BU- Before use, AU- After use

TABLE II
BACTERIAL COUNTS OF THE SWIMMING POOL WATER SAMPLES

Swimming pools	**(CFU/ml) Before use**		**(CFU/ml)after use**	
	Aerobic	**Anaerobic**	**Aerobic**	**Anaerobic**
Site A	$<1.0x10^1$	$<1.0x10^1$	$<1.0x10^1$	$<1.0x10^1$
Site B	$<1.0x10^1$	$<1.0x10^1$	$<1.0x10^2$	$<1.0x10^1$
Site C	$1.63x10^5$	$1.0x10^1$	$2.60x10^6$	$1.1x10^2$
Site D	$2.80x10^6$	$1.2x10^3$	$4.30x10^7$	$1.6x10^4$
Site E	$1.79x10^5$	$1.1x10^2$	$3.02x10^7$	$1.3x10^3$

Keys: *Swimming with less than 100 bacterial count is recommended per 100ml of water sample by EPA 2007

TABLE III
MEAN VALUES OF PRESUMPTIVE COLIFORM TEST BEFORE USE (I.E AFTER TREATMENT)

Swimming pools	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**	**Mean value**
	Total coliform (MPN/ml)	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**
Site A	<3	<3	<3	<3	<3	3	1
Site B	<3	3	<3	<3	<3	3	1
Site C	7	4	3	4	7	4	5
Site D	14	11	9	11	14	9	11
Site E	11	7	4	4	7	3	6

Keys: site A - Principle hotel -*Swimming pool water with less than
Site B- Central Hotel 100 colonies per 100ml sample of water recommended total coliform bacteria counts
Site C- Royal Tropicana Hotel Site D - Ni'ima Guest Hotel
Site E- Tahir Guest Hotel

TABLE IV
MEAN VALUES OF PRESUMPTIVE COLIFORM TEST AFTER USE

Swimming pools	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**	**Mean value**
	Total coliform (MPN/ml)	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**	**Total coliform (MPN/ml)**
Site A	<3	<3	<3	3	3	<3	1
Site B	4	3	<3	<3	3	<3	1
Site C	11	11	4	3	3	3	6
Site D	120	75	43	28	15	11	49
Site E	93	43	39	21	14	9	36

TABLE V
FAECAL COLIFORM COUNT (CFU/ML) FROM SOME OF SWIMMING POOLS

	$X10^1$	
	Before use	**After use**
Site A	0.0	0.0
Site B	0.0	0.0
Site C	0.0	1.01
Site D	4.01	6.02
Site E	1.01	2.03

Keys: *Swimming pool with less than 200 colonies per 100ml sample of water recommended faecal coliform bacterial counts by EPA 2007.

TABLE VI
FUNGAL COUNTS OF THE SWIMMING POOLS WATER SAMPLES

	Cfu/ml before use	Cfu/ml after use	%
Site A	0	0	0
Site B	0	0	0
Site C	0	0	0
Site D	12	25	61
Site E	08	16	39

V. DISCUSSION

Investigation reported that the pool water in some of the swimming pools studies was satisfactory with regard to the WHO and EPAs standard. The turbidity of most of the swimming pools was clean and clear except in site D that looks slightly cloudy. High level of turbidity can be caused by suspended particles in the water such as soil, sediment, sewage and plankton as reported by Environmental protection Agency EPA, (2007). The Temperature of the pools water after use by bathers ranged from 26.0-28.5^{0}C with highest temperature obtained at site D which also had the highest temperature of 27.5^{0}C before use. According to [13], pools with a temperature of more than 27^{0}C are more likely to be contaminated than pools with a temperature between 22-27^{0}C. increase in temperature encourages the growth of bacteria [14]. PH of most of the pools tends to increase after use by the bathers. Hence pH value is one of the good indicator of micro organisms according to [1]. [15] found that 37% of the swimming pools in South Australia had pH outside the recommended level. Furthermore, the chloride level of the pools are well treated within the standard of 1-3 ppm recommended by [5] and [1] in site A and B. Although the chloride content of all the pools diminished after used by the bathers. Site D had the lowest chloride content observed both before and after use, it could come from an ineffective treatment of the pool or bad management. And also the site is one of the place that accommodated high visitors and guests because they attracts less charges. According to the [10] reported that the presence of chloride in water is used as a measure of the effectiveness of chloride as a disinfecting agent or is used to sanitize the water in swimming pools. Nitrates and phosphates found to be high in the same site D, According to John Girvan, one of the few people to study Nitrates extensively, has said that “with nitrate in the pool”, he says, “you will get algae and other contaminants that won’t respond to normal treatment”. Some pool techs have been known to say that nitrates “lock up chlorine”, the presence of nitrate in pool water will drastically increase the sanitizer consumption [10]. Environmental protection Agency 2011 reported poor water quality and excessive chemical use are also indicators of elevated phosphate. Nitrate and phosphates in a body of water can contribute to high BOD levels.

The bacteriological quality of most of the swimming pools was also satisfactory because the mean MPN of coliform per 100ml of water was consistently below 100mark which was considered as maximum limit for recreational waters by the Ontario jurisdiction [7]). Bacteriological limits for swimming pools, however vary from country to country unlike those for drinking waters which are reached by international agreement. In the United Kingdom for instance, it is recommended that pool water should not contain any coliform organisms in 100ml of water [16]. The assumption here is that the bacteriological quality of water used in swimming pools should approximately to that of high purity drinking water.

Although the MPN values for coliforms of all the pool water fall within tolerable limits, they nevertheless differ markedly from one hotel to another. The pool water at site A and site B appear to be the least contaminated. This could be attributed to the fact that the water in these swimming pools is being continuously clarified and chlorinated. The pool water operates on a system in which the water leaves the pool at the deep end, undergoes filtration and chlorination before entering the pool again at the shallow end. The chloride level is maintained at between 0.2-0.5 parts per million (ppm). Moreover, the site A and site B are high-class (3 star) hotels. They charge higher fees and therefore attract less patronage than the rest. Consequently, the number of coliforms entering these pools from the body of bathers would be less. The high coliform counts recorded at site D could probably be attributed to the fact that it is the highly patronized of all the pools studied because they charge less fees.

Despite the fact that the mean MPN of coliforms for all pools did not exceed the limits set by the Ontario jurisdiction, complete absence of coliform bacilli from 100ml samples could have guaranteed absolute safety of the waters for swimming purposes.

Forty percent (40%) of the swimming pools had zero coliform count while only one (16.7%) had faecal coliform count of 4.0x10^{1}Cfu/ml prior to use (table 5). All the pools had varying number of total coliforms count after use by the bathers while 33.3% had faecal coliforms count. The total coliforms count tends to increase in all the pools while the level of faecal coliforms remained constant in 66.7% of the pools sampled.

Two (40%) out of the five swimming pools met up with [5; 17] standards in terms of bacterial count of less than 100 Cfu/ml before use by bathers after treatment. The high bacterial count at the other sites prior to use by bathers could probably come from contaminated water source or ineffective treatment of the swimming pools. All the pools had increment in bacterial load after use by bathers, This is in conformity with the work of the workers [16; 3; 10] who reported that

bathers tend to shed bacteria from faecal and non- faecal sources, that increases the organic matter in the pool water, there will also be a lot of bacteria present working to decompose this matter.

In present study, no dermatophyte were isolated form water, the reason for this happening may be related to the different techniques used for research or residual chlorine in water. Present finding showed that, swimming pools have a lot of saprophytic fungi and molds; therefore, we strongly recommended that these fungi can be dangerous under specific condition in immunnocompromised hosts and caused a lot of fungal infection such as keratonycosis, otitis, asthma and allergy [18].

VI. Conclusion

It can be concluded from this finding that some of the swimming pools did not conform to WHO and EPA standard for recreational waters in terms of effectiveness of treatment of swimming pools and confirmed the aesthetic unsuitability of the swimming pools.

VII. Recommendation

It is recommended that health authorities should regularly monitor the pools for compliance with regulations and frequency of treatment of these pools should also be intensified.

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