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Physicochemical and bacteriological quality of water in public outdoor swimming pools in South Nations Nationalities People Regional State, Southern Ethiopia: Cross-sectional study

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Abstract

Background: *Swimming is a fashionable and wonderful form of recreational activity, sport, rehabilitative treatment and is generally considered to be healthy exercise for both young and old people. However, the risk of infection has been linked to faecal contamination of the swimming pool due to faeces released by bathers, contaminated source water or as the result of direct animal contamination. Swimmers are infected when they swallow contaminated pool water.*

Objective: *This study was aimedto assess the physicochemical and microbiological quality of water in public swimming pools in South Nations Nationalities People Regional State, Southern Ethiopia.*

Method: *A cross-sectional study was carried out to determine quality of water in swimming pool from July, 2018 to November, 2018. A purposive sampling technique was used to select swimming pools. Physicochemical and microbiological tests were made on water sample from selected pools. Descriptive statistics were performed to construct tables for physical parameters, chemical parameters, total plate counts (TPC), thermotolerant coliform (fecal coliform), and E. coli.*

Result: *A total of 12 swimming pools were included in this study and 54 water samples were collected. All the swimming pool water samples were beyond World Health Organization's (WHO) recommendation for both PH level and conductivity. Almost all, 91.7% (11/12) of the swimming pools were violated the WHO Standard of Heterotrophic Plate Count (HPC). Five out of twelve swimming pools) were not comply with the WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. Four of the total swimming pools were confirmed for the presence of thermotolerant Escherichia coli (E. coli).*

Conclusion: *All the participated swimming pools violate the WHO recommendation for PH value and conductivity. In addition, all water samples were contaminated with mold. Half of the outdoor swimming pools violate for the lower limit value of WHO for thermotolerant (faecal) coliform count. No parasites were detected in all the swimming pools.*

Introduction

Swimming is a fashionable and wonderful form of the recreational activity and is generally considered to be a healthy exercise for both the young and old (1).The increasing attractiveness of swimming for sport, fitness, therapy or just pleasurable recreation has led to the increased use of swimming pools and the establishment of a variety of specific-use pools such as spa pools, waterslides, and more recently, hydrotherapy and wave pools. Swimming pools may be filled with fresh, marine or thermal water. Swimming pools may be classified as indoors, outdoors or both; they may be heated or unheated (2).

Different studies in the world reported that different gastrointestinal and upper respiratory infection of bathers related with unsafe swimming pools (3–5). Swimming pool waters may be contaminated by direct human contact and by waterborne pollutants from external sources (e.g., sewage, storm water, and agricultural runoff) (6). The pollution in swimming pools can be categorized in to physical, chemical and microbiological contamination (7). In many cases, the risk of illness or infection has been linked to faecal contamination of the swimming pool due to faeces, a contaminated source water oras the result of direct animal contamination (8).

Worldwide, unsafe WASH was responsible for 69% of diarrhoea cases, 14% of ARIs, and 10% of undernutrition disease burden. Additionally, it was estimated that all disease burden from STHs could be attributed to unsafe WASH(9).In Ethiopia, a significant portion of health issues, ranging from 60% to 80%, stem from communicable diseases caused by inadequate water supply, poor hygiene practices, and improper waste management (10).

If there is no regular cleaning and maintenance and proper water treatment, contamination swimming pool water may lead to different diseases outbreaks such as gastroenteritis, conjunctivitis, keratitis, trachoma, otitis, cholera, dysentery, eczema, skin rashes, typhoid, dysentery, giardiasis, cryptosporidiosis, helminthiasis, cholera, hepatitis, rotavirus infection, salmonellosis, and central nervous systems associated diseases (11).

A number of outbreaks were occurred related with *Shigella spp*., *E. coli* O157:H7, *Pseudomonas aeruginosa*, *Leptospira spp*., *Giardia lamblia*, *Cryptosporidiumparvum*, *Adenoviruses*, and *Norwalk-like viruses*, in swimming pools and recreational waters (12). The presence of *Escherichia coli* in water is indicators of fecal pollution of swimming pool (13).. In Ethiopia, there is lack of data on physicochemical and microbiological quality of outdoor swimming pools. Therefore, this study aimed at assessing the physicochemical and microbiological quality of public swimming pools in South Nations Nationalities People Regional State, Southern Ethiopia.

Method

Description of the study area: This study was carried out in selected area of South Nations Nationalities People Regional State (SNNPR) such as Dilla, Wendo Genet, Hawassa and Arbaminch town. These towns are frequently visited by local and international tourists.

Study subject: Study subject is all outdoor swimming pools located in South Nations, Nationalities and Regional States (SNNPR). The participated pools were purposively selected outdoor swimming pools from Hawassa (8 swimming pools), Wondo Genet (2 swimming pools), Dilla (1 swimming pool), and Arbaminch town (swimming pool) based on their customer frequency.

Study design: A cross-sectional study was carried out to determine physicochemical and bacteriological quality of swimming pool from July, 2018 to November, 2018.

Sample size and Sampling Procedure: A purposive sampling technique was used to select swimming pools considering bathers number. A total of 12 swimming pools were included in this study and 54 water samples were collected. Six water samples were collected from each pool of six refill swimming pools and three water samples from each pool of six recycling pool. In the case of refill pool, samples were collected at time of filling of pool, in mid time and before discarding of water from pool. In the case of recycling pool, water samples were collected three times per week. 500ml of swimming water sample collected from each pool using sterile continuer.

Methods of data collection: After obtaining permission from the owner of the swimming pool, the necessary information was collected. Furthermore, physicochemical and microbiological analysis were conducted to determine chemical and microbial quality of swimming pools.

Laboratory testing:

Water sampling: For swimming pool water sampling, a sterile bottle was immersed in the water up to the elbow, then inverted to gather the sample directly into the water about 8 inches (20 cm) beneath the surface. To obtain tap water, started by igniting the faucet and opened it completely. Let the water flow for 2-3 minutes, and then lowered the flow to fill the bottle without causing splashes. Lastly, sealed the bottle tightly with the cap. Finally the water samples were kept in cold box and transported to microbiology laboratory of Hawassa University, College of Medicine and Health Science, School of Medical Laboratory Science.

Physicochemical analysis: Physical parameters such as conductivity, and temperature, total dissolved solids (TDS) were analyzed at site of outdoor swimming pools using portable conductivity meter (JENWAY 4150). PH was also taken using portable PH-meter. Moreover, turbidity measurement was carried out at chemistry laboratory of Hawassa University using Hach-2100Q. The swimming pool water sample's turbidity was assessed using a nephlometer or turbidometer. Prior to and after incubation at 20 o C for five days, the sealed water sample's dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) were measured. The hardness was determined through colorimetric titration with an EDTA solution. The chlorine concentration in the swimming pool water was determined by observing the color change strength following the addition of diethyl-p-phenylenediamine (DPD) tablets.

Heterotrophic plate counts: Heterotrophic Plate Count (HPC) was carried out by counting the number of viable heterotrophic bacteria by inoculating pool water samples on Plate Count Agar (Oxoid, England) through pour plate technique. By using one ml of swimming water sample and nine ml of sterile distilled water, pool water samples were diluted serially into 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4} dilution. One mlof each diluted water sample was placed and 12-15ml of molten plate count agar. In order to assure complete mixing of culture media with water sample, clockwise and anti-clockwise rotation and back and forth, left and right movement was made. The plates were left until it solidified and incubated in inverted position at 37 ^{0}C for 24 hours. After the incubation period, number of colonies were counted and reported as cfu/ml(14,15).

Determination of thermotolerant (faecal) coliform: Three sets of five tubes each, containing Durham tubes, were organized in a test-tube rack. The first row's tubes held 10 ml of double-strength Mackonkey (Oxoid, England) broth, while the second and third rows' tubes contained 10ml of single-strength Mackonkey broth. A sterile pipette was used to add 10 ml of sample to each of the five tubes with Mackonkey broth. Additionally, 1ml of sample was added to each of the five tubes in the second row, and 0.1ml of sample was added to each of the five tubes in the third row. After gently mixing the contents, the rack with the 15 tubes was incubated at 37°C for 24 hours. Following incubation, each tube was observed for the presence of gas. Negative tubes were reincubated for a further 24-hour period, and then rechecked for the presence of gas. A confirmative test was conducted by taking a loopful of culture from the positive test tube and incubating it at 44°C for 24 hours. The presence of thermotolerant coliforms was confirmed if gas was present in the confirmatory broth after 24 hours at 44°C. The Most Probable Number (MPN) was determined from a statistical table. Finally, the identification of *E.coli* was made by adding kovacs reagent in positive tryptone water and observing for the formation of a red ring to indicate indole production (15).

Pathogenic isolation and identification: The 24 hr growth suspension from Mackonkey broth was inoculated on Mackonkey agar and Manitol salt agar and incubated aerobically at 35-37 ^{o}C for 24 hours. Next day the growth of the organisms were examined for Colony morphology and Gram reaction. In addition, biochemical tests were processed for identification of the organism at genus and species level.

Mold and yeast count: Swimming pool water samples underwent serial dilution using a tenfold dilution series. Initially, 10ml of water sample was mixed with 90ml of sterile distilled water to achieve a 1:10 dilution, which was then further diluted up to 1:10000. Subsequently, 1ml of the diluted sample was carefully transferred to properly labeled duplicate sterile Petri dishes. Molten potato dextrose agar, cooled to 45°C, was poured into each Petri dish. Following swirling and solidification, the plates were inverted and placed in an incubator set at 32°C. After a 72-hour incubation period, the colonies were enumerated and the colony count per 100ml was reported (16).

Direct wet smear for parasitological analysis: In order to undertake parasitological analysis for the presence of protozoan parasites; *Giardia lamblia*, *Entamoeba histolytic*a and *Cryptosporidium parvum*, water samples were concentrated

according to WHO guideline. Samples were transferred in to 15ml of conical centrifuge tube and centrifuged at 5000 RPM at 4°c for 15 minutes. The sediments were analyzed based on microscopically. By tilting conical tube, a small portion of 2-3 cm diameter of the preserved sediment was taken on clean slide. The sediment was spread over an area of approximately 2cm×1cm and covered with a cover slip. Finally, the smear was examined under the microscope using 10× and 40× objectives for parasitological water quality (occurrence of *Cryptosporidium* oocyst, *Giardia* cysts, amoeba cyst)(17).

Data quality: Trained data collectors were recruited for interview and sample collection. A standard operational procedure was followed during Swimming water samples and laboratory analysis. To ensure sterility, a test was conducted on 5% of the prepared media by incubating it for 1 day, depending on the type of media. Performance of the culture media was checked using quality control strains (*Escherichia coli*ATCC25922 and *Staphylococcus aureus* ,ATCC43300)

Data Management and Analysis: The results were recorded in a laboratory format prepared for report and later entered into Microsoft Excel. The data were then double entered in Excel for quality control purposes. Descriptive statistics were performed to construct tables for physical parameters, chemical parameters, total plate counts (TPC), thermotolerant coliform (fecal coliform) and *E. coli*.

Ethical Considerations: Support letter to different organizations was written from Hawassa University. Permission was obtained from the owners prior to specimen collection. The owners were briefed about the objective of the study. Voluntary based participation was employed during data collection.

Result

A total of 12 swimming pools were included in this study. All are concrete swimming pools and had lifeguards. Out of 12 swimming pools half were using recycling water whereas the rest refill new water for swimming (Table 3 and Table 4).Almost all of the swimming pools (11/12) provide service for both adult and children baser. All participated swimming pools provide shower service for bathers before swimming. Only one pool had facility for disinfection of bather's feet before stepping into the swimming pool. Except one, all swimming pools were using chlorination as disinfection and mode of chlorination was manual powder. Only one of swimming pool had habit of using copper sulfate as an algicidal agent.

The swimming pools water were assessed for five physical parameters: PH, Temperature (^{0}c), Conductivity (µs/cm), TDS (mg/L), and Turbidity (FTU). All the swimming pools water samples were showed PH level above the WHO recommended PH value (7.2-7.8). Among swimming pools water samples assed for total dissolved solids (TDS), two are not comply with WHO recommendation. Moreover, two of the swimming pool water samples violated the WHO cut-off value for Turbidity (FTU). However, all of the swimming pool water samples beyond (above) WHO recommendation (not exceeded 400 µS/cm) for electrical conductivity **(Table-1)**.

Table 1: Physical parameters analysis of selected swimming pools from South Nations Nationalities and Regional State (SNNPR) from July, 2018 to November, 2018.

Sample Site	Physical Parameters				
	PH	Temperature(^{0}c)	Conductivity (µs/cm)	TDS (mg/L)	Turbidity (NTU)
WS1	8.37	27.9	2250	1125	1.55
WS2	8.49	28.6	831	416	3.79
WS3	8.4	25.1	1711	856	2.85
WS4	8.67	29.5	799	400	2.99
WS5	8.7	28.8	1578	789	2.28
WS6	8.21	24.7	2904	1452	2.79
WS7	8.5	26.2	1474	737	1.57
WS8	8.35	26.2	1670	835	2.00
WS9	8.3	27.8	526	263	8.9
WS10	8.2	47.9	3827	1914	10.3
WS11	8.9	34.7	930	465	0
WS12	8.3	35.7	942	471	0
WHO	(7.2-7.8)*	35	(not exceeded 400 µS/cm)	1200	5

**WHO, 2006, WS; Water sample*

Regarding of chemical analysis two of the swimming pools violated the WHO limit for Total Hardness (mg/L as CaCO3). In addition, five of the swimming pools analyzed for Total Alkalinity (mg/L as CaCO3) were not satisfy with WHO recommendation (**Table-2**).

Related to determination of thermotolerant (faecal) coliform and *E. coli* in recycling swimming pools, two of six swimming pool did not comply to WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. From these confirmed positive swimming pools, one is positive for thermotolerant *Escherichia coli (E. coli).* However no pathogenic bacteria were identified from swimming pools (**Table 3.**). On the other hand determination of thermotolerant (faecal) coliform and *E.coli* in refill Swimming pools showed that half (3/6) of swimming pools and their corresponding sources were also violet the WHO threshold for thermotolerant (faecal) coliform count and from these positive swimming pools all are also positive for thermotolerant *Escherichia coli.* But none of water samples from swimming pools and their corresponding sources were positive for pathogenic bacteria (**Table 4**).

Concerting to Heterotrophic Plate Count (HPC), almost all swimming pools (11/12) are violet the WHO limit (<200 cfu/ml). In addition, five of the total swimming pools were positive for *Staphylococcus aureus*. However, all swimming pools had no positive result for parasitological analysis. Regarding to mold and yeast count, all swimming pools water sample positive for mold count with range of 3 to 30 CFU/ 200ml. but the yeast count was positive only in three of the swimming pools. (**Table 5**).

Table-2: Chemical parameters analysis of selected swimming Pools from South Nations Nationalities and Regional State (SNNPR) from July, 2018 to November, 2018.

Sample Site	Chemical Parameters							
	DO	COD	BOD5	Total Chlorine (mg/L)	Total Hardness (mg/L as CaCO3)	Total Alkalinity (mg/L as CaCO3)	Bicarbonate Alkalinity (mg/L as CaCO3)	Dissolved NH_3 (mg/L)
WS1	4.83 ± 0.10	21.88± 0.80	18.27 ±2.00	1.36	150	700	700	0.59
WS2	6.70 ± 0.20	22.35± 0.58	49.20 ± 6.32	2.12	240	700	700	.35
WS3	12.71 ± 0.95	25.80 ± 0.80	188.93 ± 4.83	0.13	200	500	500	0.68
WS4	11.03± 0. 20	23.88± 0.40	156.13 ± 0.12	0.00	200	500	500	0.21
WS5	10.74 ± 0.99	16.15 ± 0.61	152.20 ± 4.00	2	540	130	130	0.27
WS6	17.24 ± 0.99	16.95± 0.61	274.33 ± 3.35	3	480	160	160	0.22
WS7	11.85 ±0.15	25.88 ± 0.80	177.13 ± 6.11	0.83	440	260	260	0.52
WS8	8.47 ± 0. 20	17.88 ± 0.80	67.53 ±3.41	0.04	140	640	640	0.38
WS9	26.27 ± 0.57	38.01 ± 0.61	653.67 ±14..34	0.05	240	170	170	0.44
WS10	14.18 ± 3.37	30.28 ± 0.400	521.40 ± 8.00	0.04	50	1200	1200	0.23
WS11	9.92 ±4.63	15.08 ± 0.40	140.40 ± 100.70	0.01	45	530	530	0.05
WS12	17.73 ± 0.99	23.08 ±0.400	287.53 ± 37.28	0.02	50	480	480	0.49

Key: WS: *Water Sample,* ***BOD:*** *Biological oxygen demand,* ***COD:*** *chemical oxygen demand,* ***DO:*** *dissolved oxygen*

Table 3: . Determination of thermotolerant (faecal) coliform and *E.coli* in recycling swimming pools in SNNPR, Ethiopia.

Pool	MPN count/100ml			Confirmatory test		
	Sample 1	Sample 2	Sample 3	thermotolerant coliforms	*E. coli*	Pathogen
WS5	4	23	<2	Negative	Negative	Negative
WS6	<2	<2	<2	Negative	Negative	Negative
WS3	23	8	27	**Positive**	**Positive**	Negative
WS8	4	23	<2	**Positive**	Negative	Negative
WS9	<2	<2	<2	Negative	Negative	Negative
WS7	<2	<2	<2	Negative	Negative	Negative

Key: WS: *Water Sample.* ***MPN:*** *most probable number*

Table 4. Determination of thermotolerant (faecal) coliform and *E.coli* in refill Swimming pools in SNNPR, Ethiopia.

Pool	MPN count/100ml						Confirmatory test					
	Before swimming		Mid-weak		Before discarding		Thermotolerant coliforms		*E. coli*		Pathogen	
	Source	Pool	Source	Pool	Source	Pool	Source	Pool	Source	Pool	Source	pool
WS4	46	130	49	5	49	17	Positive	Positive	Positive	Positive	Negative	Negative
WS2	<2	17	<2	<2	<2	110	Negative	Negative	Negative	Negative	Negative	Negative
WS1	5	8	46	350	49	920	Positive	Positive	Positive	Positive	Negative	Negative
WS10	<2	22	<2	26	<2	33	Positive	Positive	Positive	Positive	Negative	Negative
WS12	<2	17	<2	110	<2	920	Negative	Negative	Negative	Negative	Negative	Negative
WS11	<2	130	<2	240	<2	1800	Negative	Negative	Negative	Negative	Negative	Negative

Key: WS: *Water Sample*

Table 5: Determination of Heterotrophic plate count (HPC), and Mycological count **of** Swimming pools in SNNPR, Ethiopia.

Pool	Heterotrophic plate count (HPC)	Staphylococcus aureus	Mould count (CFU)	Yeast count (CFU)
WS5	$2.2x10^6$ cfu/ml	Negative	9 CFU /200ml	6 CFU/200ml
WS6	$7.4x10^5$cfu/ml	Negative	3 CFU /200ml	0
WS3	$1.9x10^5$cfu/ml	Negative	2 CFU /200ml	3 CFU /200ml
WS8	$9.7x10^2$cfu/ml	Negative	30CFU/200ml	0
WS9	$1.7x10^4$cfu/ml	Negative	5 CFU /200ml	0
WS4	$3.1x10^6$cfu/ml	Positive	15CFU/200ml	0
WS2	$9.4x10^4$cfu/ml	Negative	8 CFU /200ml	13 CFU /200ml
WS1	$3.1x10^2$cfu/ml	Positive	20CFU/200ml	0
WS10	$2.1x10^4$cfu/ml	Positive	15CFU/200ml	0
WS12	$6.6x10^6$cfu/ml	Positive	9 CFU /200ml	0
WS11	$6.7x10^7$cfu/ml	Positive	20CFU/200ml	0
WS7	$1.6x10^2$cfu/ml	Negative	7 CFU /200ml	0
WHO	<200 cfu/ml			

Key: WS: *Water Sample*

Discussion

Even though the swimming pool water is not potable for drinking purpose, its quality has to meet the standards of drinking water since the individual who use it may accidentally drink it(18). Therefore, our study made assessment of water quality interims of physical, chemical, microbiological and parasitological analysis of the outdoor swimming pools found in South nation's nationalities people regional state. The indicators organisms (thermotolerant Coliform and *Ercherchia coli*) are used to check for the potential occurrence of fecal contamination(1). However, the absence of these organisms does not guarantee safety, as some pathogens are more resistant to treatment than the indicators (19).

In this study the physical parameter assessed for outdoor pools' water quality were PH, Temperature (^{0}c), Conductivity (µs/cm), TDS (mg/L), Turbidity (FTU) and Conductivity (µs/cm). Of total assessed for PH, all swimming pools indicated PH value above the WHO standard threshold (7.2-7.8). As the PH of pool waters increase scaling, chlorine inefficiency, cloudy poolsthus eye and skin irritation of the swimmers can be resulted (2,9). In addition, among swimming pools water samples assed for total dissolved solids (TDS), two are not comply with WHO recommendation.

Our study also assessed outdoor swimming pools for Heterotrophic Plate Count (HPC). As the result almost all of the swimming pools 91.7% (11/12) were violated for WHO standard Heterotrophic Plate Count (HPC). It gives an indication of the overall bacterial population within the pools. This might be because of deficiency of treatment processes. The finding of this study was higher than study conducted in Addis Ababa, Ethiopia (73.3%) (13). However similar study conducted in Ghana demonstrated that all of outdoor swimming pool water samples collected for Heterotrophic Plate Count (HPC) (26-90cfu/100ml) conforms to WHO standard (18).

The finding of thermotolerant (faecal) coliform in these swimming pools is indicator of fecal contamination and they are risks to swimmers. The current study showed that 41.7% (five out of twelve swimming pool) were not comply with WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. Similar study conducted in Bahr Dar, Ethiopia reported higher result (75%) (20). However similar study conducted in Ghana reported that all swimming pools were violated the WHO standard(18). On the other another report from Port Harcourt, Nigeria and in Kampala City, Uganda indicated that none of the swimming pools were positive for fecal coliform (11,21). The presence of thermotolerant (faecal)

coliform might be as result of possible contamination of pools by bather or animal (22). The presence of these organisms indicates that current contamination of pool water and the presence of inefficient treatment system (23).

In addition, four of the total swimming pools were confirmed for presence thermotolerant *Escherichia coli (E. coli).* This also strengthens risks of swimming pools to pose infectious disease among swimmers. Similar study conducted in Addis Ababa, Ethiopia also reported that 33.3% of swimming pools water did not meet the standard. But this study did not notified whether the *Escherichia coli* was thermogenic or not (13).

The presence of *Staphylococcus aureus* in swimming pools can be used to determine non-fecal shedding. This indicates the quality of swimming pools water. Among assessed outdoor swimming pools; five (41.7%) were contaminated with *Staphylococcus aurous*. Another study conducted in Nigeria reported as two of ten (20%) swimming pools were contaminated with *Staphylococcus aureus* (21). However study conducted in Egypt reported higher finding (94.04%) (24).

This study also was performed parasitological analysis in outdoor swimming pool water. Based on investigation, none of the water samples had parasites. Similar study conducted in Greece reported that no *Cryptosporidium* and *Giardia* cyst were isolated (8). However another similar research conducted in Paris, France reported that one sample of swimming pools was positive for *Cryptosporidium* (25). The probably reason for this variation could be attributed to the diagnostic method of the water sample from swimming pools.

The presence of fungal agents may result skin infection among swimmers. Regarding to recovery of mold and yeast, all swimming pools water samples were contaminated with mold whereas only three of the swimming pools were contaminated with yeast. Different study also indicated in world that different species of fungus were also detected from swimming pool water (7,26–29).

Conclusion and recommendation

All of the swimming pool water samples were showed pH level above the WHO recommended pH value. Above one-third of the swimming pools analyzed for total alkalinity (mg/L as CaCO3) were not satisfy with WHO recommendation. Almost all swimming pools water samples (11/12) wereviolet the WHO limit for total aerobic count. Five out of twelve swimming pools water) were not comply with WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. Five of the total swimming pools water samples were positive for *Staphylococcus aureus*. All swimming pools water samples had no positive result for parasitological analysis. All swimming pools water samples were contaminated with mold whereas only three of the swimming pools were contaminated with yeast. Therefore, the government and other concerned bodies should apply close supervision on swimming pools. . Training should be given on infectious prevention and adherence to quality criteria set by WHO .

Abbreviations: SHPC: Standard Heterotrophic Plate Count, WHO: World Health Organization, HPC: Heterotrophic Plate Count, TCC: Total Coliform Count FCC: Fecal Coliform Count, SNNPR: South Nations, Nationalities and Regional States, RPM: Revolution Per Minute. WS: Water Sample.

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