

# Bacteriological and Physicochemical Assessment of Water Quality of the Public Swimming Pools in Klang Valley Malaysia

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## Research Article

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# Abstract

**Background:** Water is essential for life and it been used for various activities such as drinking, bathing, and recreational purposes and also one of the modes of the transmission of the disease.

**Objective:** The objective of this study to assess the presence of bacteriological and physicochemical quality of swimming pools' water in Lembah Klang, Malaysia.

**Methodology:** Seven water samples collected from outdoor and indoor swimming pools (hotel, apartment, and public swimming pool) in Lembah Klang, Malaysia. Water samples were collected in sterile bottles (30 ml). Physicochemical parameters were determined using water quality testing kit pH & chlorine apparatuses. The water sample was cultured and incubated. The presence of bacteria was counted by the total bacterial count method.

**Result:** The ranges of mean values of the various chlorine level parameters of the selected water samples investigated for the apartment, hotel, and municipal were,  $0.56 \pm 1.01$ ,  $0.77 \pm 0.95$ , and  $1.19 \pm 0.91$ . All the physicochemical parameters except conductivity values were within the permissible limits of the World Health Organization (WHO) standards 2006 and American National Standard for Water Quality in Public Pools and Spas (ANSI/APSP) 2015. The mean, standard plate count of water samples from the selected apartment, hotel, and municipal's swimming pools were,  $28407.14 \pm 28469.05$ ,  $8192.86 \pm 10556.36$ , and  $3257.14 \pm 6250.17$  which above the WHO Guideline limit, thus signifying contamination.

**Conclusion:** The study recommends improvement in the personal hygiene of swimmers, adequate cleansing of the pools, and enforcement of standards by the government.

## 1. Introduction

Throughout history from regeneration to regeneration, swimming has been popular in practically in the humanities and nations. As the sciences and technology evolved, thoughts about the risks of disease transmission associated with swimming in the pond, ocean, or swimming pool, in recent history. Moreover, different public health scientists unthinkingly assumed that there could be a relation between the units of faecal contamination as well as contamination from bathers, and the risk of acquiring certain illnesses during swimming activities, this relation was not effectively demonstrated until the 1950s which research had done by Moore B in article name Sewage contamination of coastal bathing waters in England and Wales.

However, the Centers for Disease Control and Prevention (CDC) has recently reported that there have been numerous epidemics of disease as a result of using public swimming pools, precisely the existence of the Protozoan *Cryptosporidium*. This has been occurring because many public pools had not correctly cleaned (Brad Kelechava, et al., 2015) [1]. The endorsed to the pollution of the swimming pool in the study area by faecal substance and other firm waste materials. This benefaction has been recognized as prevention for some public health risks to users, due to the contamination of swimming pool water. Bacterial contamination toward the swimming pool water can result in pathogenic bacteria, causing infections to swimmers. Nevertheless, these contaminants can be obtainable into swimming pool water from swimmers, from the pool filters, or occasionally from defects in pool engineering (George Osei-Adjei, et al., 2014).[2] Notwithstanding, recreational waters may contaminate by direct excretion by the bathers (vomits, urine, etc.), transport on the body, or growth within the filter bed (Hoseinzadeh E et al., 2013) [3].

In many cases, waterborne infectious causing diarrhoea and the most common bacteria with a total of three thousand cases reported every year in the United States alone (Yoder et al., 2012a, 2012b)[4,5]. According to the Malaysia Health Ministry, the prevalence in 2013 of waterborne, typhoid, cholera, hepatitis A and dysentery were 47.79, 0.73, 0.58, 0.41, and 0.28 per 100,000 of the population correspondingly reported in 2013 (Dr. Milton Lum, 2015) [21]. The Infections caused by swallowing the contaminated water by the bacteria and fungi reported in most recent years, from swimmers (Brewster et al., 1994; Kiyohara et al., 2006) [6, 7]. The risk of infection and disease linked to the contamination of the swimming pool water, consequently some due to the faecal related by the bather or contaminated source of water or may be due to the directly contaminated animals (birds, frogs or mouse) (WHO, 2006)[6,7]. Besides, faecal matter contributes to the water when a person has an accidental faecal release (diarrhoea stool) or when individual faecal material on swimmers' bodies are washed into the pool (CDC, 2001a)[10]. Conversely, some other causes are due to non-faecal human sheddings such as vomiting, skin disease, mucus, or saliva in the swimming pools give the potential to transmit the microorganisms (pathogens). Moreover, fungi and viruses may also lead to skin infection, which comes to infected water. The primary pathogens, mostly bacteria, can also be the shield from the user and transmitted I water (WHO, 2006; Kokebe Yedeme et al., 2017) [8, 11].

## 2. Methodology

### 2.1 Study design

The study had conducted in Klang Valley, Malaysia between June until August 2016. Quantitative research with correlation was used with a random sampling method. The research is a cross-sectional study. This study does not have time dimension it depends on the differences existing on behalf of change the following intervention and the sample are select based on existing differences on behalf of random allocation. The cross-sectional design measure through alternatively a process of change.

## **2.2 Study area**

The study piloted in Klang Valley, Malaysia mostly the sample collected at the Apartments, hotels, and public swimming pool around the Klang Valley area. Thus, Klang Valley is an attractive and developing country and the centre of Malaysia. It the most popular area of leaving, tourism, and underwritten through a faster development compared to other cities in Malaysia. The size of Klang Valley is 2900 KM and located in the centre of Selangor State. It located at the West Coast of Malaysia with a widespread range of flat land than the East Coast of Malaysia with a population of almost 7.53 million peoples in 2015 (Jabatan Perangkaan Malaysia, 2015) [12]. The temperatures remain constant. The maximums temperature is between 32°C and 33°C and not exceed more than 38.5°C. Besides, the minimums temperature is between 23.4°C and 24.6°C and have never fallen below 14.4°C. Klang Valley had received a minimum amount of 2,600 mm rain in a year and in June to July are relatively dry, but mostly it will exceed 131 millimetres per month.

## **2.3 Sample size calculation**

This sample size will determine the objective of the research which to determine the bacteriological count in of the Public Swimming Pools in Klang Valley, Malaysia. By using the Statistical Package for the Social Sciences (SPSS) version 24.0. This software calculates the sample size needed for the sample.

## **2.4 Data analysis**

The research using a Pearson correlation coefficient test. The data collection was systematically arranged, and the resulting data tabulated and entered using specific program used to develop the analysis which is using Statistical Package for the Social Sciences (SPSS) version 24.0 and Microsoft Excel 2010.

## **2.5 Physicochemical analysis of the water samples**

Chlorine and pH determined by using the rainbow model 78 all in one test kit for the pool or spa. The temperature measured at the poolside by using a standard 100°C thermometer.

## **2.6 Bacteriological analysis of the water samples**

The water samples were determined using a bacteriological indicator. Plate count agar and serial dilution method used to determine the amount of the bacteria and it was incubated at 37°C for 24 hours for all colony counting (WHO, 2006; APHA, 1998) [8,13]. All microbial analysis was done by following strict aseptic techniques of microbiology procedures. All the data collected and analyzed by using SPSS (SPSS, RRID:SCR\_002865) and Microsoft Excel 2010 (Microsoft Excel, RRID:SCR\_016137). To find the mean and standard deviation of the bacteria.

## **2.7 Ethics Approval and Consent to Participate**

This research did not involve any human participation as according to ethic approval by Management & Science university (MSU) research board since there is not human and animal involve.

## **2.8 Human and Animal Rights**

No Animals or Humans were used for these studies.

## **2.9 Conflict of interest (COI)**

The paper did not have any conflict of interest.

# **3. Results And Analysis**

## **3.1 Prevalence of chlorine level and bacteriological status**

The study in chlorine level in the apartment shown that there are about 85% water sample in the apartment, low in chlorine level and 15% water sample in the apartment, high chlorine level. The standard plate count was 100% contaminated for the apartment. For hotel, the chlorine level is much like the apartment, and there are 85% water sample in hotel low in chlorine and 15% water sample in a hotel high in chlorine. Moreover, the standard plate count for hotel shows, about 28 % water sample high in bacteria count and 71 % water sample, low in bacteria count. Conversely,

difference result show in a municipal water sample. Were there about 57% of water sample in municipal show low in chlorine level and 43% of the water sample is high in chlorine level. The standard plate count for municipal shows that 85% of the water sample is low in bacteria and about 15 % water sample shows a high count in bacteria.

Comparison of the mean of physicochemical quality and microbiological quality shown in table 3.1.1.

Table 3.1.1: Comparison of mean of physicochemical quality.

Type	Adult swimming pool		
	Apartment	Hotel	Municipal
<b>Chlorine (ppm)</b>	0.56±1.01	0.77±0.95	1.19±0.91

Table 3.1.2: Comparison of mean of microbiological quality.

Type	Adult swimming pool		
	Apartment	Hotel	Municipal
<b>Standard plate count (Cfu/ml)</b>	28407.14±28469.05	8192.86±10556.36	3257.14±6250.17

Frequency standard of the physicochemical parameters of swimming pools in Klang Valley, Malaysia, presented in table 3.1.1, while Table 3.1.2 shows the value of the standard plate count. The finding indicates that the chlorine and standard plate count of the apartment, hotel, and municipal water swimming pool.

### 3.2 Compare the mean of chlorine level quality in three different group of apartment, hotel and municipal swimming pool in Klang Valley, Selangor.

Graph 3.2.1, shows the mean value of the chlorine for three types of swimming pool water sample the municipal shown the higher value at 1.19±0.91, followed by the hotel at 0.77±0.95 and apartment at 0.56±1.01 respectively. The P-value for Municipal is 0.018 (<0.05) significantly higher than apartment and hotel.

### 3.3 Compare the mean of standard plate count quality in three different groups of apartment, hotel and municipal swimming pool in Klang Valley, Selangor.

And Graph 3.3.1 shows the mean value of the standard plate count for three types of the swimming pool water sample. The apartment showed the highest amount of standard plate count at 28407.14±28469.05, followed by Hotel at 8192.86±10556.36 and the Municipal at 3257.14±6250.17 respectively. The significant value of the apartment is 0.050 (<0.05) highly significant compared to the hotel and municipal.

### 3.4 Correlation between standard plate count and chlorine level quality in three different groups of apartment, hotel and municipal swimming pool in Klang Valley, Selangor

Table 3.4.1: Correlation between Chlorine Apartment and Bacteria Apartment

Correlations			
		Chlorine Apartment	Bacteria Apartment
Chlorine Apartment	Pearson Correlation	1	-0.124
	Sig. (2-tailed)		0.792
	N	7	7
Bacteria Apartment	Pearson Correlation	-0.124	1
	Sig. (2-tailed)	0.792	
	N	7	7

A Pearson's correlation runs to determine the relationship between Chlorine Apartment and Bacteria Apartment. There were a very weak, negative correlations between Chlorine Apartment and Bacteria Apartment ( $r = -0.124$ ,  $N=7$ ,  $p=0.792$  ( $P > 0.05$ )).

Correlation value  $r = -0.124$  of would be a "week negative correlation."

Table 3.4.3: Correlation between Chlorine Hotel and Bacteria Hotel

Correlations			
		Chlorine Hotel	Bacteria Hotel
Chlorine Hotel	Pearson Correlation	1	-0.439
	Sig. (2-tailed)		0.325
	N	7	7
Bacteria Hotel	Pearson Correlation	-0.439	1
	Sig. (2-tailed)	0.325	
	N	7	7

A Pearson's correlation test shown the relationship between Chlorine Hotel and Bacteria Hotel. There was a moderate, negative correlation between Chlorine Hotel and Bacteria Hotel ( $r = -0.439$ ,  $N=7$ ,  $p= 0.325(P>0.05)$ )

Correlation value  $r= -0.439$  of would be a "moderate negative correlation."

Table 3.4.5: Correlation between Chlorine Municipal and Bacteria Municipal

Correlations			
		Chlorine municipal	Bacteria Municipal
Chlorine municipal	Pearson Correlation	1	-0.625
	Sig. (2-tailed)		0.134
	N	7	7
Bacteria Municipal	Pearson Correlation	-0.625	1
	Sig. (2-tailed)	0.134	
	N	7	7

A Pearson's correlation test shown a relationship between Chlorine Municipal and Bacteria Municipal. There was a strong, negative correlation between Chlorine Municipal and Bacteria Municipal ( $r = -0.625$ ,  $N=7$ ,  $p=0.134 (>0.05)$ )

Correlation value  $r= -0.625$  of would be a "Strong negative correlation."

## 4. Discussion

To comply with the WHO and ANSI/ APSP guidelines provided, swimming facilities must display regulations to identify the correct activities to implement in the pool environment.

Seven samples random taken from apartment, hotels, and municipals swimming pool in Klang Valley, Selangor. The table and graft are the result occurrence of chlorine level and bacteriological status, analyzed. The chlorine level from the apartment's swimming pool shown about 85% of water samples had low chlorine levels and others, high in chlorine level. The standard plate count for seven apartment's swimming pool provides a result, high in bacteria with an output of 100%.

Seven random swimming pool water samples had taken form hotels; the chlorine level is much similar to the apartment. Which there were 85% water samples show, low in chlorine, and another 15% high in chlorine. The standard plate count for the hotel swimming pool water indicates about 28 % of the sample in the hotel has high bacteria count and 71 % low in bacteria count.

There is a different result shown for the municipal's swimming pool water sample. Were there about 57% of water samples in municipal show low in chlorine level and 43% have high in chlorine level. The standard plate count for municipal's swimming pool shows about 85% of the water sample is low in bacteria and others 15% having high bacteria counts.

Notwithstanding, the standard chlorine level of the swimming pool had been standardized by WHO and ANSI/ APSP at 1.5 up to 4 PPU and the standard plate count should below 200 CFU/ml. The result indicates that the municipal have good management of the swimming pool compared to hotels and apartment, this shows that the management of the apartment and hotel did not follow the recommended and guideline that had provided accordingly.

Moreover, investigation and observation, the growth of bacteria are due to a few factors where some of the swimming pools are the open swimming pool. The open swimming pool has access to outbreak sources example birds, cats, dogs, frogs, rats, and insects. Some of the apartments and hotels contain faeces of the birds and cats in the swimming pool area. The maintenance or the management of the swimming pool did not perform proper maintenance to clean the swimming pool area from the faeces. Besides, observation in the open swimming pool, there are a lot of birds and frogs take a shower at the edge of the swimming pool, which increases the source of the bacteria.

The comparison means of chlorine level quality in three different groups of the apartment, hotel, and municipal swimming pool show, the apartment is the lower at 22% than the hotel and municipal by 34% and 44% respectively due to improper maintenance by apartment and hotel

management. The level of chlorine should be monitoring every day to keep the swimming pool water low in photogenic bacteria and fungi. Using a low concentration of chlorine will affect the reading of the chlorine level and will increase the bacteria growth. This study support by Yoder et al., (2005) [16], said that improper maintenance of public and semi-public facilities frequently fails to protect the public against chlorine-sensitive pathogens. Besides, this statement supported by Al Khatib et al., (2003) [17], said that Analysis of the presence of free chlorine level for disinfection revealed that all samples contained free chlorine which is much less than the required level. Chlorine used as a disinfectant in all of the swimming pools and must be present continually and in sufficient concentrations to protect against the survival of newly introduced pathogens. Still, the reasons might be using less amount and concentration of chlorine which may be incomparable to the volume of water, presence of high level of organic matter, microbial load, higher temperature (Chlorine easily evaporate) and remains unavailable. Kokebe Yedeme et al., (2017) [11], mention the physicochemical factors such as chlorine level one of the critical keys to controlled to ensure the effective decontamination and to avoid damage to the pooled material. If the water pH is alkaline, Chlorine antiseptic enactment decreases, it will provide the growth of fungal. Generally, physicochemical parameters of the water have a strong influence on the efficiency of the disinfection process. Factors like pH, the turbidity of the water, the concentration of chlorine, and contact time, influence the efficiency of disinfection with chlorine.

Compare the mean of standard plate count in three different groups of the apartment, hotel, and municipal swimming pool show, the Standard plate count of the apartment is the highest at 71% compared with Hotel and municipal by 23% and 8% respectively. The bacteria in the apartment is high due to contagion from the animal and bather. Also, low chlorine residual sanitization this supported study by Indabawa et al. (2015) [14], said that the high bacterial count at the other sites before use by bathers and animal could probably come from the contaminated water source or ineffective treatment of the swimming pools. The swimming pool had an increment in bacterial load after use by bathers and animal, and this conforms to the work of the workers who reported that bathers tend to shed bacteria from faecal and non-faecal sources, which increases the organic matter in the pool water, there will also be a lot of bacteria present working on decomposing this matter. It also supported by Prescott et al., (2002) [15] said that it also isolated these species of fungi from public swimming pools in Egypt and Iran. *Fusarium* knew for ocular infections in humans and animals.

The result from the correlation analysis between standard plate count and chlorine level in three different groups of apartment, hotel and municipal swimming pool show that there is week negative correlation between chlorine level in the apartment and standard plate count in the apartment with the correlation value of  $r = -0.124$  with a significant value of  $p = 0.792$  which it is not significant. Moreover, the correlation test also thru between chlorine level hotel and standard plate count hotel which shows a moderate negative correlation with a value of  $r = -0.439$ , with significant value  $p = 0.325$  result as no significant value. The test also completed to chlorine level municipal and standard plate count municipal; show the correlation value  $r = -0.625$ , which is a strong correlation but not significant with a value of  $p = 0.134$ . Similar conclusions made by Rasti et al. (2012) [18] also reported no significant difference between the enduring chloride in contaminated and non-contaminated swimming pools. Moreover, Rabi et al. (2008) [19] also had the same support, that there is a correlation association between swimming pools adulteration and the time of water sample collection. In this result, Maida et al. (2008) [20], claimed that the quality of water depends on chloride concentration and the number of swimmers appearing in the pool.

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## 6. Graphs

The graphs are available in the Supplementary Files.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Graph3.2.1.png](#)
- [Graph3.2.1.png](#)
- [Graph3.3.1.png](#)
- [Graph3.3.1.png](#)
- [Graph3.4.2.png](#)

- Graph3.4.2.png
- Graph3.4.4.png
- Graph3.4.4.png
- Graph3.4.6.png
- Graph3.4.6.png