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# Bacteriological and chemical quality of swimming pools water in developing countries: a case study in the West Bank of Palestine

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Monitoring was carried out during summer 2000 in all the swimming pools in the West Bank of Palestine. Fifty-eight water samples, collected from 46 swimming pools, were examined for *Coliforms* and bacterial species including *Streptococci*, *Salmonellae*, and *Staphylococcus*. *Salmonellae* were isolated in 21 out of 23 samples. All of the examined samples from the swimming pools water were unacceptable according to the Palestinian and WHO standards. Extensive efforts are required to improve the water quality of the swimming pools in the West Bank, mainly public awareness, training of governmental inspectors, operators and owners of the swimming pools, in addition to a strict system for monitoring of the water quality.

*Keywords:* Recreational swimming pools; water quality; developing countries.

## Introduction

Recently, there has been an increased interest in the construction and operation of swimming pools in the West Bank of Palestine. The reason is that there is no marine water easily accessible. Various forms of pollution, mostly from the bathers themselves but also from other sources are introduced almost continuously into the water of the swimming pools. If left untreated these pollutants build up in the water with the risk of infection from an increasing number of bacteria and other microorganisms and of reduced safety through loss of clarity due to suspended particulate matter (UK Department of the Environment 1981, 1983, 1987). As a result, there is an increased interest in the pollution of swimming pool water because of health hazards contained in them. It is essential to monitor water quality in pools for changes in chemical and physical characteristics that may result in irritation to the bather's skin, eyes, and mucosal barriers or may adversely affect disinfection. Microorganisms of concern are typically those from the bather's body and its orifices and include those causing infections of eye, ear, upper respiratory tract, skin, and intestinal or genitourinary tracts. Water quality depends on the efficiency of disinfection, the number of bathers in the pool at any one time, and the total number of bathers per day (APHA 1992, 1995).

All the tested swimming pools are disinfected outdoor pools. In such kind of pools, faecal *Coliform* bacteria are the primary indicators of contamination from animal pets, rodents, storm

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water runoff, and human sources. Supporting indicators include the heterotrophic plate count and species of *Streptococcus*, *Staphylococcus* and *Pseudomonas*. These organisms account for a large number of swimming pool associated illnesses and may be resistant to the effect of chlorine (Klapes and Vesley 1988).

APHA (1995) provides standards for total and faecal *Coliforms*, faecal *Streptococci* with the addition of *Salmonella* and others.

According to Al-Khatib *et al.* (2000) and Park (1980), throughout any year, 95% of samples should not contain any *Coliform* organisms in 100 ml, no sample should contain *E. coli* in 100 ml, no sample should contain more than 10 *Coliform* organisms in 100 ml, and *Coliform* organisms should not be detected in 100 ml of any two consecutive samples.

Sanitizers are added to the swimming pool water for the purpose of disinfection. Some common sanitizers are: chlorine, bromine, iodine, fluorine, ultraviolet light, ozone, potassium monopersulphate. The widely sanitizing agent in use in the West Bank of Palestine is chlorine for it is the only agent that combines the following: cheap, stable, available, effective and colourless. The main forms of chlorine used for swimming pool water disinfection in the West Bank are the liquid chlorine and dry (tablet) chlorine. According to UK Department of Environment (1979), Tamminen (1996) and Al-Khatib *et al.* (2000) the safe chlorine residual should be in the range of 1–2.5 ppm.

This study was performed to ascertain the microbiological quality of swimming pool waters of the West Bank of Palestine, in addition to some of the chemical characteristics. The aim of this research is to find out if the recreational swimming pools throughout the West Bank are operated under ideal conditions and make sure that these pools do not constitute a health hazard to the bathers. Pools are good recreational places; they are places where one can practice one of the best sports, i.e. swimming. The importance of swimming pools in the West Bank as a recreational tool acquires double meaning where the freedom of movement is very restricted for the youth, and there are no alternatives to move or utilize the free time in a productive way. Maintenance of pools is essential; skill and knowledge are prerequisites. There are international standards for the construction and maintenance of pools; how far these standards are followed in the West Bank is a matter in question. This analysis tries to probe this issue through presentation of results obtained by analysing the collected samples from 46 swimming pools in the West Bank. The presence of classical bacteriological indicators has been verified, including faecal pollution, *Coliforms*, species of *Streptococci*, *Staphylococcus* and *Salmonellae*.

## Materials and methods

During the bathing season April–September 2000 (mainly in July), swimming pool water samples were collected from 46 swimming pools representing all swimming pools in the West Bank of Palestine. The samples were collected by the Environmental Health Department of the Palestinian Ministry of Health for inspection purposes. From each swimming pool, one, two, three, four, eight, or 13 samples were collected. Eighty-two samples were examined for total *Coliforms* (81 for faecal *Coliforms* 32 for faecal *Streptococci*, 23 for *Salmonellae*, 81 for *Staphylococcus*) and 25 samples were examined for total bacterial count. More than one test for some swimming pools was repeated when the microbial quality of the water examined was found to be unacceptable. Forty-four and 67 samples were examined for free chlorine and total chlorine, respectively, to ensure the chemical quality of the swimming pools water.

Total *Coliforms*, faecal *Coliforms* and faecal *Streptococci* were enumerated by the Most Probable Number (MPN) method inoculating series of five tubes, using Lactose Broth–Brilliant Green Bile Broth and Azide Dextrose Broth Ethyl Violent Broth, respectively (APHA 1992).

The presence of *Salmonellae* was ascertained filtering 1 litre of swimming pools water through 0.45  $\mu\text{m}$  membrane. Buffered Peptone Water, Rappaport Vassiliadis Broth and Desoxycholate Citrate Agar were used as pre-enrichment, enrichment and isolation steps, respectively. Biochemical and serological identifications were performed on isolated strains by multi-tests and sera.

The samples were meant to be taken at the time considered to be peak hours, 12–2 p.m. during which maximum load of bathers exists and the pools practically operate.

## Results

The values of all microbiological and chemical parameters are shown in Table 1. Out of the tested 44 samples for free chlorine, 27 (61.4%) of the samples have a concentration less than 1 ppm, 15 (34.1%) of the samples between 1–2.5 ppm and two samples more than 2.5 ppm. This means that only 34.1% of the swimming pools have acceptable disinfected swimming water within the standard limits. This result directly reflects the presence of microbiological contamination of the swimming pools.

It has been found that all 46 swimming pools were microbiologically contaminated by at least one indicator, and 17 (37%) of them were microbiologically contaminated with two or more indicators.

Out of the 46 swimming pools existing in the West Bank, the water in 29 of the swimming pools (63%) was examined once (mainly for faecal *Coliform* and total *Coliform*) during the year 2000 swimming season. Sampling and examination were repeated for the other swimming pools as follows: 11 (22.9%) swimming pools were tested twice, three swimming pools were tested three times, three swimming pools were tested four, 18 and 13 times, respectively.

Out of the 82 samples tested for total *Coliform*, 69 (75.3%) of the samples were with good quality. And out of the 81 samples tested for faecal *Coliform*, 69 (81.2%) were with good quality. Most of the tested samples (94.1%) for *Staphylococcus* were free of this microorganism. The opposite is true for *Salmonellae*, since 91.3% of the tested samples were positive. In the samples tested for *Streptococci* indicator, it was found that only 56.5% were with good quality.

**Table 1.** Range values and frequencies of total *Coliforms*, faecal *Coliforms* and faecal *Streptococci*, Total *Staphylococcus*. (TC-FC-FS, TS) ( $n$  100  $\text{ml}^{-1}$ ), *Salmonellae* (S) (+/–/1), Total Bacterial Count (TBC) ( $n$  1  $\text{ml}^{-1}$ ) and the free chlorine residue (ppm)

Range values and frequencies													
TC	FC		FS		TS		S	TBC	Free chlorine residual				
0–10	64	0	69	0	13	0	80	–	2	1–2000	10	0–0.9	27
>10	18	>0	12	1–10	5	50	1	+	21	>2000	15	1–2.5	16
				15–888	5							>2.5	1
Total	82	81		23		81		23		25		44	

Regarding the total bacterial count, it was found that 60% of the tested samples were within the limits of the standards and 40% were with bad quality.

**Discussion**

The results of this study show that all of the 46 swimming pools are microbiologically contaminated. Almost all of these swimming pools are located within or in proximity of residential areas, which are home to approximately two million people. There are no other easily accessible bathing areas for swimming in the West Bank of Palestine. More than 70% of these swimming pools were recently constructed (since 1995).

The results showed that only few swimming pools are faecally polluted, but all the swimming pools are affected by at least one organism.

Swimming pools require a lot of chemical and mechanical attention. This requires a good experience from the operators to know what they are doing and operating. Circulation, filtration, and chemistry are three concepts that are vital to understanding the successful functioning of a swimming pool system. Proper water chemistry, filtration, and good circulation go hand in hand to produce clean and clear water with good quality (Griffiths 1994a,b, UK Department of Environment 1987, Tamminen 1996). The low experience in the operation, maintenance, and chemistry of the recently constructed swimming pools in the West Bank made it difficult to have good water quality. Some of the operators do not know the required concentration of chlorine in the water. Sometimes they put large quantities of chlorine at once in the swimming water, which make the concentration exceed the standards and cause hazards to the swimmers. At other times concentration lower than the standard values required can be found. Some times one can find crowded swimming pools, while stopping the circulation and filtration systems. As a result, the water quality is often far from the acceptable guidelines and standards.

In order to see the effect of the concentration of the free chlorine residual on the other biological and microbiological indicators, many cross tabulations have been performed. The final summary is presented in Table 2. As it is clearly seen from this table, there is an inverse relationship between presence of TC, FC, FS, S and TBC, and the concentration of free chlorine residual. Most of the contaminated samples have a free chlorine residual less than 1 ppm.

**Table 2.** Effect of the free chlorine residual concentration (FCR) (ppm) on total *Coliforms*, faecal *Coliforms* and faecal *Streptococci*, Total *Staphylococcus*. (TC-FC-FS, TS) ( $n$  100 ml<sup>-1</sup>), *Salmonellae* (S) (+/-/1), Total Bacterial Count (TBC) ( $n$  1 ml<sup>-1</sup>)

		TC		FC		FS		TS		S		TBC	
		0-10	>10	0	>0	0	>0	0	>0	+	-	0-2000	>2000
Free Chlorine Residue (ppm)	0-0.9	17	9	18	8	5	6	26		11	2	7	5
	1-2.5	12	2	14		5	1	14		6		3	2
	>2.5	1		1		1	1	1		1		1	
Total		30	11	33	8	11	8	41	0	18		11	7

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The inspection procedure by the operators of the swimming pools for the swimmers is also ineffective. Some times there are no regulations for the swimmers. Swimming suits may be a source of different pathogenic or opportunistic pathogens. There are also no physicians for the inspection of the health or the skin of the swimmers. So you can find some swimmers with infected wounds, which might be a source of microorganisms in the swimming water. In addition, there are no restrictions or limitations on the number of swimmers in the swimming pools, while Al-Khatib *et al.* (2000) indicate that in the shallow area of the swimming pool, which forms 60–80% of the swimming pool area and has a depth less than 1.5 m, the permissible number of swimmers should not exceed one swimmer  $\text{m}^{-2}$ . In the deep area, in which the depth is greater than 1.5 m, the permissible number of swimmers should not exceed one swimmer  $2.2 \text{ m}^{-2}$ . This explains the existence of faecally contaminated swimming pools, and the bad hygienic quality of some others.

In addition to that, many of the swimming pools are not isolated from green areas and playing yards, and some have shared areas with restaurants. So one can find different organic wastes dumped in or floating on the surface of the swimming water in the pools. Also, the source of water for some of the swimming pools is faecally contaminated due to its location near domestic wastewater cesspits.

None of the samples was examined for *Pseudomonas*, yeasts, viruses, or pathogenic *Protozoa* while this is expected to exist, since *Pseudomonas* is a bacteriological indicator of faecal pollution and good indicators for recreational water quality (APHA 1995). Some yeast species are pathogens for humans and animals (Rose and Harrison 1989), and therefore, swimming pools water should be tested for yeasts in the West Bank.

## Conclusions and Recommendations

The results of this study show that none of the swimming pools in the West Bank of Palestine are in line with the limits of the Palestinian and International regulations for swimming and bathing. All the swimming pools water are affected by the current absence of strict regulations, monitoring and control systems. This situation could result in hazards for the swimmers and the surrounding communities due to the spread of microorganisms, including opportunistic pathogens.

From the analysis of the previous results the following recommendations can be drawn:

- a better and more strict supervision by the Ministry of Health should be operated.
- efficiency training and education of swimming pools supervisors and operators in circulation, filtration, and chemistry of swimming water should be conducted.
- public education in simple personal and applied hygiene should be emphasized.
- a time schedule for the biological and chemical examination of swimming pools water to assure the good quality of swimming water should be followed.
- overcrowding should be avoided and pool surroundings and facilities should be kept clean and hygienic.

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