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Full Length Research Paper

Assessment of Sanitary Conditions in the Main Swimming Pools in Gaza Strip (2010 – 2013): Palestine

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Abstract. Approximately 1.7 million inhabitants of 378 km^2 area of Gaza Strip don't have enough recreational areas, except Gaza beach which suffers from sewage pollution as well as some public and private swimming pools which considered as merely recreational places. The main objective of this study is to assess the microbiological quality of swimming pools water in Gaza Strip to assure its health safety for swimmers. Sampling and analysis were conducted by the Ministry of Health over a period of about four years (2010-2013). Samples were collected from seven central swimming pools in Gaza Strip periodically and examined for Total Coliforms and Faecal Coliforms. In addition, *Staphylococcus aureus*, *Faecal Streptococcus* and *Pseudomonas aeruginosa* were isolated from the swimming pools samples with different percentages. Percentages of microbial contamination, concentration of free chlorine and pH level were examined in the studied swimming pools and compared with the international standards and the annual trends were demonstrated. The results show that, about 75% of the recorded data regarding pH level are unacceptable, while 100% of the recorded data about the concentration of free chlorine within the swimming pools are unacceptable. About 57% of the collected samples were contaminated by Total Coliforms, 39% were contaminated by Faecal Coliforms, 46% were contaminated by *Staphylococcus aureus*, 21% were contaminated by *Pseudomonas aeruginosa* and 18% were contaminated by *Faecal streptococci*. The annual trends show increase in percentage of contamination to be the worst during the year 2013. Therefore, proper intensive surveillance and water chlorination is needed periodically.

Keywords: Sanitary conditions, swimming pools, microbiological quality, Gaza Strip, Palestine

ABBREVIATIONS
(APHA): Wastewater American Public Health Association; (CCB): Common Coliform Bacteria; (CFU/100ml): The number of colony forming units per 100 milliliters; (FC): Fecal coliform ; (HOCl): Hypochlorous Acid; (MFC): Membrane Filter Culture (MFC) technique; (mg/l): Milligram / Liter; (mLS): Membrane Lauryl Sulfate; (MoH): Ministry of Health (MPN /100 ml): Most-probable-number per 100 milliliters; (OCl^-): Hypochlorite Ion ; (PCBS): Palestinian Central Bureau of Statistics; (pH): A term used to indicate the alkalinity or acidity of a substance; (ppm): Part per million; (TC): Total coliforms ; (UNEP): United Nations Environmental Program; (UNICEF): United Nations Children's Emergency Fund; (VJ) : Vogel-Johnson agar; (WHO): World Health Organization.

1. INTRODUCTION

The escalation in population growth as well as the rising demand for places used for recreational activities due to its diverse advantages has put public and political pressure on water purveyors to make every water body available for multipurpose use in safe and healthy situation according to the related international regulations (Standish-Lee and Loboschefsky, 2006). In the region of 1.7 million dwellers (PCBS,2013), and about 376 km^2 of superficies (UNEP, 2009) the southern part of Palestine which is represented by Gaza Strip is considered as one of the most densely populated areas in the world (PCBS,2013). Because of their isolation, the inhabitants of this area between the Mediterranean, Egypt and the Israeli occupation are reliant on being self-sufficient (Sarsour and Omran, 2011). According to this blockage, the coast of Gaza Strip constitutes a vital area for the population, as the citizens don't have enough recreational areas, that Gaza beach can be considered the only recreational site which led to make the beaches usually very crowded during the summer with bathers (Elmanama et al., 2006).

This lonely place has been subjected to sewage pollution, waste dumping and the situation was aggravated when sewage treatment systems collapsed during the recent hostilities, leading to the daily deposition of tens of thousands of cubic meters of raw sewage into the Mediterranean Sea, that microbiologically contaminated seawater has been detected along the shoreline region of the Gaza Strip (Hilles et al., 2014; UNICEF, 2012). Hence, the development of swimming pools in different recreational areas whether private or public sectors became widely used by diversity of Gazans to escape from the hot summer for entertainment and exercise. This trend indicates that the leisure activities, including water-based recreation, will continue to increase (Kay et al., 2004), particularly that the swimming pools can provide many advantages over land-based activities for people of all ages and physical abilities (Zwiener et al., 2007). Thus, those responsible for monitoring and managing recreational waters are likely to face increasing challenges as the number of users' increases and recreational uses diversify (Pond et al., 2005), that regardless of the value for the swimming pools, many studies consider them as posing a risk for infection by certain fast-growing environmental bacteria (Abd El-Salam, 2012) as swimming pools are used by a wide variety of people with different health conditions and are for that reason more susceptible to infection from opportunistic bacteria (Rabi et al., 2008). So the effects of the health hazards that recreational water users face will gain increased prominence in the future (Kay et al., 2004).

A vast diversity of microorganisms can be found in pools and other waters used for recreation, originating from different sources, such as humans, animals or the environment (Thorolfsdottir and Marteinsson, 2013). In principle, that any microorganism capable of spreading by the faecal-oral mechanism can be involved in pool waterborne infection as water is an excellent vehicle for them (Barna and Kádár, 2012). The main objective of this study is to assess the microbiological quality of swimming pools water in Gaza strip to assure its healthy status for swimmers.

2. MATERIALS AND METHODS

2.1. Data collection

Data about swimming pools in Gaza Strip were collected from the records of (MoH), over a period of four years (2010-2013); sampling and analysis were conducted by Water Control Department of MoH within its role in monitoring the quality of the swimming pools water through a routine program for inspection purposes. The authors followed the results over years 2010 - 2013 and applied their statistical analysis to make comparison between the four years and detected the most polluted swimming pools according to local and international standards, then discussed the main causes, and its health impact, and finally settled their recommendations.

2.2. Sampling Technique for Microbiological Analyses

The mean of results of 7 central swimming pools in Gaza Strip were computed from the records of MoH during the recent four years (2010-2013), average and percentage were performed. Free chlorine concentration, pH, Total coliforms (TC), Fecal coliform (FC), *Faecal streptococci*, *Staphylococcus aureus* and *Psuedomonas aeruginosa* were studied. Percentages of microbial contamination were compared with international standards and the annual trends were demonstrated.

Sampling was performed according to Standard Methods for the Examination of Water and Wastewater American Public Health Association (APHA) (Eaton and Franson, 2005). Non-reactive borosilicate glass bottles of 500ml were used to collect samples for microbiological examinations that had been cleansed and rinsed carefully, given a final rinse with deionized or distilled water, and sterilized 121ºC for 15 minutes. A sufficient amount of sodium thiosulfate ($Na_2S_2O_3$) was added to all glass containers prepared for the collection of swimming pools water to eliminate residual chlorine effect which kills Coliforms. Before collection of the samples, any external activities such as filling the pools from another water pipe or water pump were stopped, in addition, the filtration process of the swimming pool water also was stopped and the bathers were asked to stay calm until the sampling process complete to ensure that there is no contamination may occurred by these factors or accessories.

On the other hand, samples were taken from different sides and places of the pools to cover all the area of the pool. The samples were filled with swimming pools water by entering or flooding the tightly closed glass container at least 25 - 50cm below the pools water surface, then the cover of the container opened gradually and cautiously to ensure that it will not be submerged quickly in case it was opened rapidly to ensure that the sodium thiosulfate will stay in the bottle. After filling the bottle with the exact amount of pool water, the bottle closed tightly under the surface of the pool water and was taken out to continue the other procedures. Numbering and naming of the samples were done directly after taking them out from the water and it carried out quickly to the ice box under a temperature up to 4ºC. A prepared sheet especially for swimming pools samples was used in order to write down names, numbers and field measurements of the samples. In the same time, field measurement such as pH and free chlorine were performed as soon as the team reaches the place of the swimming pool. Finally, the samples were transferred to the Public Health laboratory in order to perform the microbiological tests during 2 to 6 hours.

2.3. Microbiological Analyses

Appropriate methods of analysis were used in order to give clear interpretation and presentation of the information gathered. Referring to WHO recommendation, there is the priority parameter to be monitored for sea and fresh water quality monitoring programs for protection of human health against fecal contamination (WHO, 2003). Accordingly, the WHO Guidelines for Safe Recreational Water Environments propose values for the microbiological quality of marine recreational waters, through developing a mandatory standard for intestinal *enterococci* in the revision of the Bathing Water Directive; currently only a guideline value exists (Pond, et al., 2005). Concerning microbiological analyses, for standard total count, the mesophylic plate count agar 1ml infusion technique was used, with incubation at 37°C for 48h. For TC, the 100ml filtration technique was used, with membrane Lauryl Sulfate (mLS) medium incubated at 37°C for 24h. For Faecal coliforms, the 100ml filtration technique was also used, with M-FC medium incubated at 44.5°C for 24h. For *Pseudomonas aeruginosa*, the 100ml filtration technique was used, with m-pseudomonas agar incubated at 44°C/48h, following verification of green colonies with casein hydrolysis on milk agar incubated at 37°C for 24h. For *Staphylococcus aureus*, the most probable number technique was used, with m-staphylococcus UNEP modified (1994) broth incubated at 37°C/48h, following re-culture of positive tubes on Vogel-Johnson (VJ) agar incubated at 37°C/48h, and once again re-culture of typical colonies on brain heart infusion broth (37°C/24h) and final confirmation using coagulate test (WHO, 2003). Data obtained from samples results, were entered and plotted using EXCEL software, and then compared it with WHO standard and guidelines for safe recreational water environments.

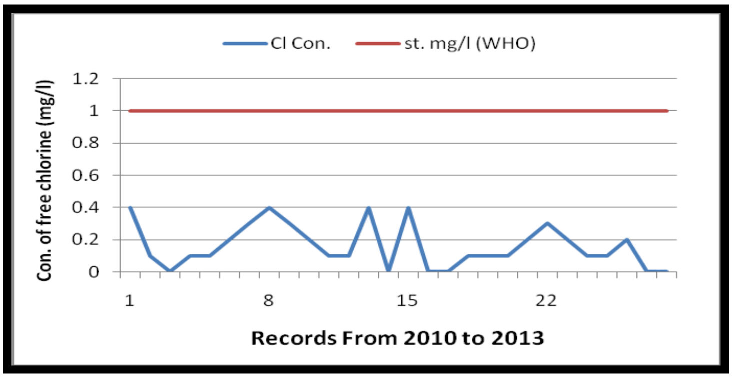

Fig 1: Chlorine Concentration and WHO Level

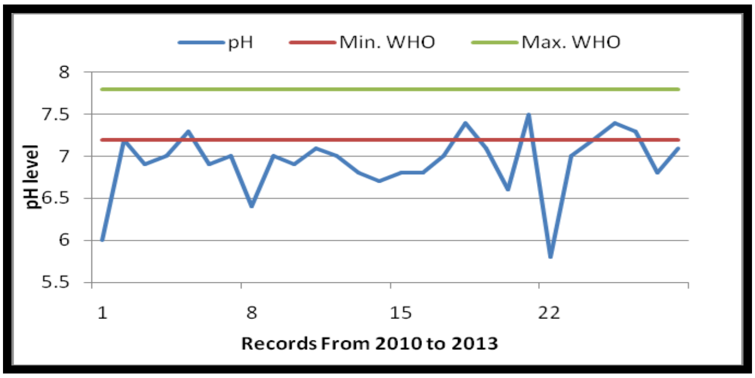

Fig. 2: pH in Swimming Pools and WHO levels

3. RESULTS AND DISCUSSIONS

Various studies accentuate that the microbiological quality of swimming pools is best measured by using FC bacteria as the primary indicators of Fecal contamination (Al-Khatib and Salah, 2003; Eaton and Franson, 2005). Faecal coliforms constitute a particular group of bacteria primarily found in human and animal intestines and wastes (Figueras and Borrego, 2010). These bacteria are widely used as indicator organisms of the presence of wastes in water and the possible presence of pathogenic (disease-producing) bacteria (Anderson et al., 2005). Total coliforms have been used as indicator during many years in evaluating water quality for several water uses with respect to domestic waste (Figueras and Borrego, 2010; Kashefipour et al., 2002; Owili, 2003). Microbial contamination as TC and FC should be ≤ 10 and 0 respectively in the swimming pools according to recommended standards by the WHO. Supporting indicators include the heterotrophic plate count and species of Streptococcus, Staphylococcus and Pseudomonas (Pond et al., 2005).

The finding of this survey revealed that almost all samples of the targeted swimming pools in the Gaza Strip are highly contaminated at least with one or two types of microbial organism, and this result could be related to the bather load, that high density of swimmers might lead to a risk of contact with pathogens and transmission of diseases (Abd El-Salam, 2012; Rabi et al., 2008). Also, this microbiological contamination could attributed be to the poor disinfection in the surveyed swimming pools water (Fig. 1), that according to WHO adequate routine disinfection should be achieved with a free chlorine level of 1 mg/l throughout the pool in order to avoid any microbial contamination, and pH level should be 7.2 to 7.8 (WHO, 2003). This finding is compatible with results of local study for Al-Khatib and Salah (2003) which emphasized that all samples were unacceptable according to the WHO standards, since all samples were contaminated by at least one microbial indicator, 37% were contaminated with two or more indicators and only 34.1% had acceptable water. In the same context, a study in Greece four out of the five investigated pools were contaminated with at least one microbial indicator and two out of the five (40%) were contaminated with two or more indicators (Papadopoulou et al., 2008). In Italy swimming pool results were better than the present study finding, were only around 16% of indoor pools and 25% of outdoor pools did not conform to the Italian legal requirements , and in 65% of non-compliant samples, only one parameter exceeded the required standards (Dallolio et al., 2013).

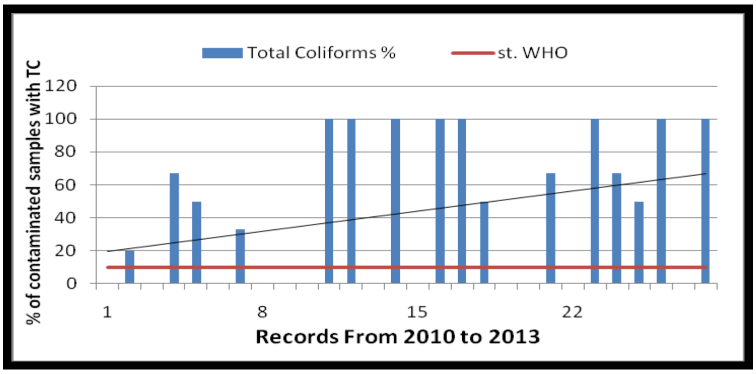

Fig. 3: Total Coliforms Trends and WHO Standard

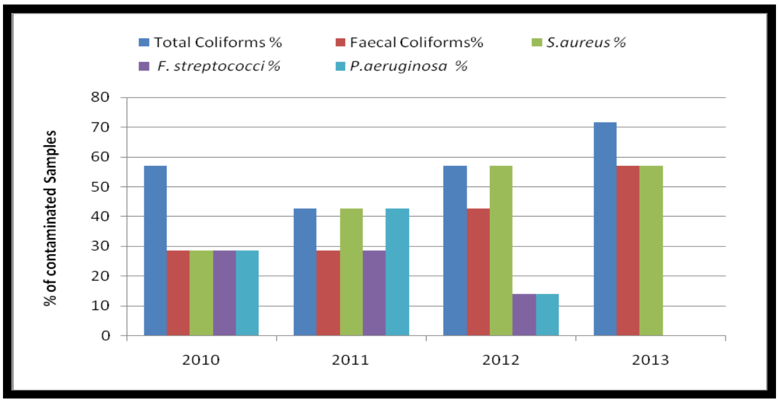

Fig. 4: Percentages of Contaminated Samples

To achieve good disinfection of water with chlorine or a salt of hypochlorite, control of pH is very important. At a pH of 8.0, for example, 21% of the free chlorine exists in the hypochlorous acid form (acting as a strong, fast, oxidizing disinfectant), and at a pH of 8.5, only 12% of that chlorine exists as hypochlorous acid. For this reason, the pH value should be kept relatively low and within defined limits. A pH value of swimming pool water between 6.5 and 7.6 is generally preferred, and chlorine is generally considered ineffective at pH 8 or above. Together, hypochlorous acid and OCl^- are referred to as free chlorine (WHO, 2003). In this study the results of the seven central swimming pools in Gaza Strip and within the recent four years (2010 - 2013) showed that, 100% of the recorded data about the concentration of free chlorine within the swimming pools were unacceptable according to WHO standards (at least 1 mg/l) (Fig. 1), and 75% fell outside the recommended pH range and unacceptable according to WHO standards level (7.2 to 7.8) as shown in (Fig.2). This poor disinfection would provide justification for the high percentage of microbiological contamination that about 57% of the collected samples were contaminated by TC (Fig. 3), that about 39% of the collected samples were contaminated by FC according to WHO standards (0CFU) (Fig. 4).This finding is compatible with finding of local Al Khatip and Salah (2003) which revealed that most of the contaminated samples (61.4%) have a free chlorine residual less than 1 ppm, and also agree with Abd El – Salam (2012) in Alexandria, Egypt who found that free residual chlorine, more than half (80%) of the pools do not comply with the standards, and the majority 53.3% of the analyzed samples revealed that pH values violated the standard range (7.2-7.8). In addition to results of Rabi et al., (2007) in Amman-Jordan were 38% of the swimming pools have unacceptable level of disinfection and do not comply with the standards limits (concentration of free residual chlorine less than 1 ppm), but contradict with its pH compliance as the majority (87.7%) of the analyzed samples in analyzed swimming pools in Jordan revealed that pH value met the standard (7.2-7.8).

Water samples and swabs from surfaces were taken in 15 public indoor swimming pools in Moscow, Russia, in 6 pools, the level of faecal contamination of the water did not meet current standards, with common coliform bacteria (CCB) levels ranging from 10 to 57 CFU/100 ml in surface samples and from 0 to 32 CFU/100 ml in deeper samples, the standard being no more than 1 CFU/100 ml (Sinitsyna et al., 2012). These statistics were compatible with that of Iranian results which revealed that, 18.2 % of the swimming pools water samples exhibited high rates of TC, and FC (Hajjartabar 2004), and with Jordanian results were the prevalence of contamination among the swimming pools in Amman, Jordan is much higher than other countries where TC was detected in 43.5% of water samples and FC was positive in 94.7% of samples contained TC (Rabi et al., 2008). However, these figures were much higher than that reported in Egypt were the TC was >3.0 MPN /100 ml in 43.3% of water samples and FC was positive in 53 .8% of samples which contained TC > 3.0 MP N/100 ml.

Pseudomonas aeruginosa is considered as the most frequently referred to opportunistic pathogen bacterium in connection with the pool and spa environment , and it's a nutritionally highly versatile, ubiquitous aquatic bacterium capable of adapting to various environmental conditions including water, vegetation, soil and various niches of the human body (Barna and Kádár, 2012; Allen et al., 2004). There is no numerical limit proposed for the presence of *P. aeruginosa*; however some authors recommended its use in interpreting the results of sanitary and microbiological surveys (Khan et al., 2010; Leclerc et al., 2002). The *P. aeruginosa* group may cause wide variety of disease such as wound and burn infections, otitis media, eye infection, septicemia and meningitis it can overtly infect humans mostly with compromised immune system but not infrequently also healthy ones (Tirodimos et al., 2010).

Also, *Fecal streptococci* has received extensive support as functional indicators of microbiological water quality, since they show a high and close relationship with health hazards associated with the water use, mainly for gastrointestinal symptoms. They are typically found in the gastrointestinal tract of warm blooded animals, they are more persistent in environment than the Fecal coliforms (Figueras and Borrego, 2010; Layton et al., 2010).There is a growing support that the bacterium *Streptococus feacalis* and some viruses, which are associated with human and animal feaces, may be better sewage pollution indicators since they are more resistant to environmental stress and survive longer. This is for example reflected in the Icelandic regulation for recreational water (Figueras and Borrego, 2010; Owili, 2003).

About 46% of the collected samples were contaminated by *Staphylococcus aureus*, about 21% of the collected samples were contaminated by *Pseudomonas aeruginosa* and about 18% of the collected samples were contaminated by *Faecal streptococci* (Fig. 4). In Papadopoulou et al. (2011) study 32.9% of the samples did not conform to the recommended microbiological standards, 12.1% were contaminated with *P. aeruginosa*. In Iran, *P.*

aeruginosa grew in 63.6% of the water samples (Hajjartabar, 2004).

For a complete overview of microbiological risks in the man-made recreational water installations, consideration should be given to a diverse group of non-faecally derived microorganisms that are carried by persons – or incidentally by animals – with or without symptoms of various infections and shed into the water or onto surfaces of objects in the pool and spa facilities and may infect susceptible hosts by plain encounter (Barna and Kádár, 2012). An opportunistic pathogenic bacterium, *Staphylococcus aureus,* is frequently found as member of the microflora of skin or nasal mucosa of healthy individuals and is invariably shed when immersing into the pool water . Its presence in the water in high numbers may be a consequence of crowding and inadequate disinfection and may cause skin infections (rashes, impetigo, otitis externa) wound infections, conjunctivitis, etc. Density of coagulase positive staphylococci in water has been proposed as an indicator with relevance for both the bather load and the effective disinfection (Begier et al., 2004).

In Moscow, Russia swimming pools results, although *Escherichia coli* and *Enterococcus faecalis* were not found in any water sample, *Pseudomonas aeruginosa* was found in the water of 3 pools, while *S. aureus* was found in all water samples at levels of 5-295 CFU/100 ml at the surface (Sinitsyna et al., 2012). For instance, *staphylococci and pseudomonas* were found to be many times more resistant to chlorine than coliforms and it is therefore not surprising to recover *staphylococci and pseudomonas* in water samples in which no coliforms were found (Tirodimos et al., 2010).

4. CONCLUSION

The most popular swimming pools in Gaza Strip were highly contaminated and unsafe to be used for recreation. In addition, the annual trends show increase in percentage of contamination to be the worst during the year 2013. This could be attributed to different causes such as the bather load and high density of swimmers, besides poor disinfection processes and monitoring efforts are which was out of place according to the international regulations. Also, the levels of the pH in most of the swimming pools in Gaza Strip were not suitable to offer the best disinfection process. According to the results, swimming pools in Gaza Strip represent an important source of negative health impact on the public, particularly on the sensitive people, who have low immunity. Therefore, proper intensive surveillance and water chlorination periodic evaluation and follow up from the official sides are urgently needed to be implemented to minimize the health risk. Public awareness regarding visiting swimming pools is required to decrease the volume of the adverse impacts on health. Also, more mandatory regulations are needed to be performed in order to control private businesses in the field of recreational areas and swimming pools in Gaza Strip.

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