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# Microbiological Quality of Drinking Water and Prevalence of Waterborne Diseases in the Gaza Strip, Palestine: A Narrative Review

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## Abstract

Water quality and occurrence of water-borne diseases in the Gaza strip are vivid examples for most developing societies. In recent years, the quality and quantity of groundwater, the only source of waters in the Gaza strip, have deteriorated markedly. A general rundown of the infrastructure and water distribution networks, in particular, the spread of cesspools, excessive use of pesticides and fertilizers, and improper treatment and disposal of wastewater remain major contributing factors to the continued deterioration in the water status in the Gaza strip. Without a doubt, the (Israeli)-Palestinian conflict had a clear negative impact on the water sector in the Gaza strip. Apparently, there is a dire need to adopt the WHO's water safety plan in the management of Gaza's water supply systems from catchment to consumer's tap in order to maintain the sustainability and quality of water resources and prevent outbreaks of waterborne diseases. Therefore, this review has been prepared to highlight the overall picture of the water dilemma in the Gaza strip in the last years and in addition, to identify the sources, sorts, levels, and health risks of consequence to microbial contamination of water. The impact of political conflicts on the water sector in the Gaza strip also was reviewed. Furthermore, recommendations were formulated in order to assist and guide future researchers, stakeholders, and policymakers to avoid the more exacerbation of water contamination as well as to protect public health.

**Keywords**

Fecal Coliforms, Gaza Strip, Microbiological Water Contamination, Public Health, Total Coliforms, Waterborne Diseases

## 1. Introduction

Globally, water occupies more than 70% of the Earth's surface, nevertheless less than 3% is available as freshwater and only 0.01% of freshwater is accessible for human consumption, while the rest is restricted in the Arctic and the Antarctic as glaciers (Mishra & Dubey, 2015). Over the ages, accessing freshwater has been the subject of sustained attention by communities because the safe water is a fundamental need for sustaining life free from health risks and diseases (WHO, 2008). Nowadays, water problems are still the main dilemma because of its serious effects on human health and the environment. It is estimated that over 780 million individuals could not possess access to potable drinking water (UNNC, 2010; Onda et al., 2012). Waterborne infectious diseases remain a major source of morbidity and mortality in the world, causing more than 2.2 million deaths every year, the majority of whom reside in developing countries (WHO, 2018). Moreover, unsafe drinking water represents about 88% of the global burden of diarrhea especially among children of poor countries, which accounts about 4.1% of the total Disability Adjusted Life Years (DALYs) (WHO, 2008; Das et al., 2014). On the other hand, the severity of the suffering of water challenges and the spread of waterborne diseases are significantly less in the developed countries (WHO, 2011; Nabeela et al., 2014).

Despite the general convection that the water safety plan (WSP) was a step in the right direction and the best approach for protecting water supply systems from catchment to consumer taps, execution of WSP is still limited in some countries (WHO, 2008; Summerill et al., 2011).

Gaza strip's waters are becoming over the years more and more scarce and polluted. Numerous natural and anthropogenic factors contribute to making Gaza strip the worst-case scenario in term of water problems (Al-Agha, 1995; Shomar, 2006; Shomar, 2011b). A number of studies and research have reported high microbiological and chemical pollution levels of groundwater, mainly due to over-abstraction and improper disposal of wastewater (Qahman & Larabi, 2006; Shomar et al., 2006; Yassin et al., 2006; Shomar et al., 2010a; Shomar, 2011b; Abbas et al., 2013; Jabal et al., 2015). Nevertheless, the incidence of waterborne diseases among the population of Gaza strip has not been given sufficient attention by previous studies.

Although the negative environmental impacts of brackish water desalination technology, small-scale desalination plants were proposed by the Palestinian water authority in order to address the negative impacts of aquifer salinity (El-Nakhal, 2004; Jaber & Ahmed, 2004; Baalousha, 2006; Frenkel & Gourgi, 1995; El Sheikh et al., 2003; Weinthal et al., 2005). Nowadays, the vast majority of Gaza's population relies on the desalinated water for drinking purpose since more than 150 small-scale desalination plants are spread along the Gaza strip as commercial projects. However, the lack of surveillance and monitoring programs for desalinated water production and storage processes and also transportation by tanker trucks might expose desalinated water to contaminants which pose a genuine health hazard (Al-Agha & Mortaja, 2005; Amr & Yassin, 2008; Al-Khatib & Arafat, 2009; Aish, 2011; Abudaya et al., 2014). On the other hand, as a consequence of poor economic conditions of Gaza's households, almost 17.3% of Gaza's households cannot afford the average price of improved water of 3.0 NIS/$m^3$ (Al-Ghuraiz & Enshassi, 2005; UNICEF, 2017). Low level of Gaza's citizens with water supply service has been reported especially concerning water quality, quantity, and continuity (Al-Ghuraiz & Enshassi, 2006).

Latest reports of both United Nations Relief and Works Agency for Palestine Refugees (UNRWA) and the Palestinian Ministry of Health (MOH) indicated that diarrheal diseases are the most important causes of childhood morbidity. Furthermore, an increased trend of the prevalence rate of diarrhea over the previous year in the Gaza strip has been noted as the prevalence rate of diarrheal diseases among children had increased markedly from 4017.1 cases per 100,000 individuals in 2009 to 6909.1 cases per 100,000 individuals in 2012 (UNRWA, 2013; MOH, 2017).

To the best of our knowledge, there have been no reviews on microbiological water quality and prevalence of waterborne diseases in the Gaza strip, Palestine. Therefore, the aim of the current narrative review is to highlight the causes, sources, sorts, levels, and health risks of microbial contamination of water in the Gaza strip. The impact of political conflicts on the water sector in the Gaza strip also was reviewed. Furthermore, recommendations were formulated in order to guide the future researchers and administrative agencies to initiate relevant studies and develop new policies to prevent further deterioration of water quality and ensure safe drinking water to the public in the country.

## 2. Description of the Study Area

The Gaza strip is a densely populated narrow strip lies on the southern corner of Palestinian Mediterranean sea coastline (**Figure 1**). It has a surface area of 365 $km^2$ and around two million inhabitants. It consists of five governorates namely: North Gaza, Gaza, Middle zone, Khan Younis, and Rafah governorate, and also each governorate includes some of the municipal areas (UNCT, 2012; PCBS, 2016). Gaza strip is located in an arid and semi-arid zone with annual precipitation range between 230 mm to 410 mm and the rainfall occurs during the period between October and April (Shawwa, 1994; Aish et al., 2010).

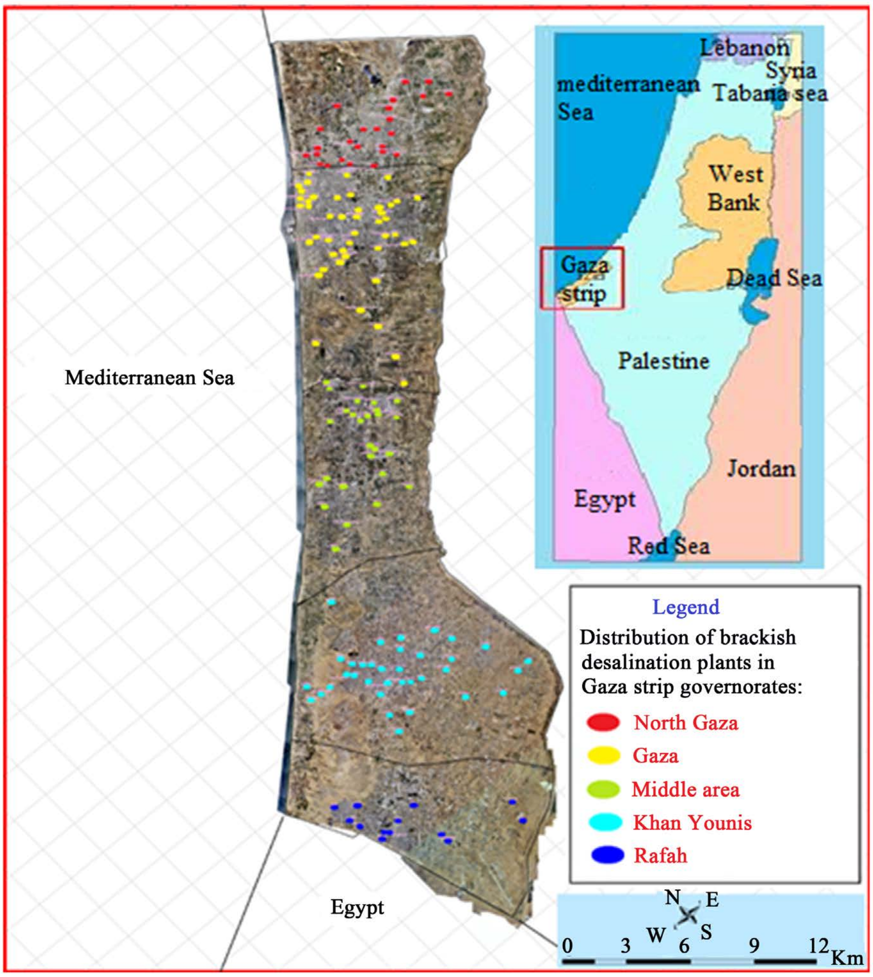


Figure 1. Gaza strip map and distribution of small-scale water desalination plants in the five governorates.

## 3. Microbial Contamination of Water in the Gaza Strip

Several studies have been carried out to investigate the microbial contamination of Gaza's waters as well as the periodic monitoring program of water quality running by the Public Health Laboratories in the Palestinian Ministry of Health (Table 1).

The outcomes of the water quality monitoring program of Palestinian ministry of health between 1999 and 2003 showed high levels of microbiological contamination of water where 13% and 20% of water wells samples and municipal networks samples were contaminated with total coliforms, respectively. Whereas 8% and 12% of water wells samples and municipal networks samples were contaminated with fecal coliforms, respectively (Yassin et al., 2006).

The strip-wide investigation which included 1056 water samples from rain-fed cisterns, municipal networks, and small-scale desalination plants indicated that 8.6% and 3.9% of rain-fed cisterns samples exceeded the WHO limits for both total coliforms and fecal coliforms, respectively. While 15.5% and 7.1% of municipal networks water samples were found contaminated with total coliforms

Table 1. Proceeding studies regarding microbiological contamination of Gaza strip waters.

| Sampling area | Source of water samples | Total no. of samples | % of samples with total coliform | % of samples with fecal coliform | % of samples with other microbial pathogens | References |
|---|---|---|---|---|---|---|
| Gaza strip governorates | Desalination plants, tanker trucks, and water storage tanks at the kindergartens | 50 samples | 20.0% of desalinated water samples, 37.0% of tanker trucks samples, and 60.0% of kindergartens water storage tanks samples | 13.0% of desalinated water samples, 28.0% of tanker trucks samples, and 40.0% of kindergartens water storage tanks samples | - | (Zaqoot et al., 2016) |
| Gaza governorate | Desalination plants | 81 samples | - | 27.0% of desalination plants samples | Escherichia coli: 28.3% of desalination plants samples | (Abu Heen & Albattnigi, 2015) |
| Gaza strip Governorates | Groundwater wells | 152 samples | - | - | Escherichia coli O157: 9.9% of groundwater samples | (Sharif, 2003) |
| Gaza strip governorates | Inlet and outlet water of small-scale water desalination plants | 92 samples | 41.0% of inlet water samples and 45.5% and 31.8% of outlet water samples | 27.3% of inlet water samples and 31.8% of outlet water samples | - | (Motasem & Yunes, 2013) |
| Middle zone governorate | Water wells, desalination plants, tanker trucks, distribution networks, and households water storage tanks | 3929 samples from groundwater wells, 7815 samples from distribution networks, and 1042 from desalinated water | 15.8% of desalination plants samples, 26.7% of tanker trucks samples, 74.0% of distribution samples, and 75.7% of household storage tanks samples | 5.3% of desalination plants samples, 6.7% of tanker trucks samples, 26.0% of distribution networks samples, and 40.3% of household storage tanks samples | Fecal streptococcus: 0.0% of desalination plants samples, 20.0% of tanker trucks samples, 27.0% of distribution networks samples, and 19.0% of household storage tanks samples | (Aish, 2013) |
| Gaza strip governorates | Inlet and outlet water from desalination plants | 88 samples | 15.2% of inlet water and 19.3% of outlet water | 11.4% of inlet water and 13.8% of outlet water | - | (Abudaya & Hararah, 2013) |
| Gaza strip governorates | Desalinated water and fifteen brands of indigenous and imported bottled water | 20 samples from desalinated water and 15 samples from bottled water | 25.0% of desalinated water samples and 53.3% of bottled water | 15.0% of desalinated water samples and 40.0% of bottled water | - | (Bashir & Aish, 2011) |
| Gaza strip governorates | Small-scale desalination plants | 40 samples | 10.0% of inlet water samples and 25.0% of outlet water samples | 5.0% of inlet water samples and 15.0% of outlet water samples | - | (Aish, 2011) |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Gaza strip governorates | Groundwater wells and water networks | 164 samples | 28.0% of groundwater wells samples and 32.0% of water networks samples | 8.0% of groundwater wells samples and 12.0% of water networks samples | - | (Mayla & Amr, 2010) |
| Gaza strip governorates | Rain-fed cisterns, distribution networks, and desalinated water | 1056 samples | 8.6% of rain fed-cisterns samples, 15.5% of the distribution networks, and 15.2% of desalinated water | 3.9% of rain fed-cisterns water samples, 7.1% of the distribution network, and 7.0% of desalinated water | Fecal Streptococcus: 0.7% of rain fed-cisterns water samples, 4.8% of the distribution network, and 1% of desalinated water. Pseudomonas: 21.2% of the distribution network and 6.5% of desalinated water | (Al-Khatib & Arafat, 2009) |
| Khan Yunis governorate | Water wells and distribution networks | 3462 samples | 22.0% of water wells samples and 25.0% of networks samples | 7.0% of water wells samples and 12.0 of networks samples | - | (Amr & Yassin, 2008) |
| Gaza governorate | Water wells and distribution networks | 27,367 samples | 13.0% of wells and 20.0% of networks samples | 8.0% of wells, and 12.0% of networks samples | - | (Yassin et al., 2006) |

and fecal coliforms, respectively. As for water samples collected from small-scale desalination plants, 15.2% and 7% of samples were contaminated with total coliforms and fecal coliforms, respectively. Moreover, twenty-four and twelve water samples from municipal water and small-scale desalination plants were found contaminated with Pseudomonas, respectively (Al-Khatib & Arafat, 2009).

Another study conducted by Motasem & Yunes (2013), between August 2008 and April 2009 to assess the microbial contamination of inlet and outlet water of 22 small-scale water desalination plants. Ninety-two water samples were analyzed for total coliforms and fecal coliforms. The results suggested that 41% and 27.3% of inlet water samples were contaminated with total coliforms and fecal coliforms, respectively. Whereas 45.5% and 31.8% of outlet water samples were contaminated with total coliforms and fecal coliforms, respectively. The higher percentage of contaminated outlet water samples than the inlet water samples confirm that desalination filters could be a potential source of water contamination. High rates of bacteriological contamination in desalinated water in the Gaza strip where there was a statistically significant relationship data between water quality and the spread of waterborne diseases in the Gaza strip have been demonstrated by Al Khatib et al. (2015).

The results of the survey conducted between 1 April and 30 October 2009 which involved 164 water samples from wells and municipal networks stated that 28% and 32% out of water wells samples and municipal networks samples were contaminated with total coliforms, respectively while 8% and 12% out of water wells samples and municipal networks samples were contaminated with total coliforms, respectively (Mayla & Amr, 2010). Similar results were found in Khan Yunis governorate between 2000 and 2006 since total coliforms and fecal coliforms contamination in water wells and municipal networks exceeded the WHO's limits (Amr & Yassin, 2008). El-Nahhal & Harrarah (2013) also concluded that groundwater in Khan Yunis governorate is non-potable due to apparent chemical and biological contaminations.

The situation in the other governorates is not the best, a microbiological survey was done in the middle zone governorate in 2009 which encompassed of 9, 19, 15, 77, and 231 water samples from water wells, small-scale water desalination plants, tanker trucks, vendor shops, and household's water storage tanks which showed 20% and 6.7% of water samples collected from small-scale water desalination plants were contaminated with fecal coliforms and total coliforms, respectively. 20%, 6.6% and 26.7% of samples collected from tanker trucks were contaminated with fecal streptococcus, fecal coliforms, and total coliforms, respectively. 75% and 27% of samples collected from desalinated water storage tanks in vendor shops were contaminated with total coliforms and fecal streptococcus, respectively. Consistent high level of contamination found in households drinking water storage tanks, since 76% and 40% of water samples were contaminated with total coliforms and fecal coliforms, respectively (Aish, 2013). The same situation was found by (Aish, 2011) where 10% and 5% out of 20 water samples from inlet to small-scale water desalination plants in Gaza strip were contaminated with total coliforms and fecal coliforms, respectively, whereas 25% and 15% out of 20 water samples from outlet to small-scale water desalination plants were contaminated with total coliforms and fecal coliforms, respectively. The contamination percent of water samples from outlet to small-scale water desalination plants was more than that of the water samples from the inlet to small-scale water desalination plants, which may be attributed to the poor operational condones in the plants as well as bad quality of filters that may play a significant role in the formation of bacterial biofilms inside the filters.

The microbiological survey over a period from January until April 2012 which encompassed 88 small-scale desalination plants spread throughout Gaza's five governorates displayed that 17.6%, 13.8%, 20%, 27.3%, and 18.2% of the inlet water to small-scale desalination plants in North, Gaza, Middle zone, Khan Younis, and Rafah governorate were contaminated with total coliforms, respectively. About 17.6%, 13.8%, 15%, 18.2%, and 16.6% of the inlet water to small-scale desalination plants in North, Gaza, Middle zone, Khan Younis, and Rafah governorate were contaminated with fecal coliforms, respectively. Furthermore, analogous results were found for the outlet water where 11.8%, 6.9%, 10%, 18.5%, and 9.1% of the outlet water from small-scale desalination plants in North, Gaza, Middle zone, Khan Younis, and Rafah governorate were contaminated with total coliforms, respectively. Nearby 11.8%, 10.3%, 5%, 27.3%, and

37.3% of the outlet water to small-scale desalination plants in North, Gaza, Middle zone, Khan Younis, and Rafah governorate were contaminated with fecal coliforms, respectively (Abudaya & Hararah, 2013).

The recent study conducted by Zaqoot et al. (2016) confirmed the microbiological quality deterioration of water in small-scale desalination plants, tanker trucks, and kindergartens water storage tanks. The results showed 20% and 13% of water samples collected from small-scale desalination plants were contaminated with total coliforms and fecal coliforms, respectively. 33% and 28% of water samples obtained from tanker trucks were contaminated with total coliforms and fecal coliforms, respectively. 60% and 40% of water samples gathered from kindergarten's water storage tanks were contaminated with total coliforms and fecal coliforms, respectively.

Abu Heen & Albatnegi (2015) study showed that, out of 81 and 27 water samples collected from groundwater and desalinated water, 37% and 18.5% of groundwater samples were contaminated with fecal coliforms and *E. coli* bacteria, respectively, whereas approximately 29.6% and 25.9% of desalinated water samples obtained from small-scale desalination water plants were contaminated with fecal coliforms and *E. coli* bacteria, respectively. Also, the study observed that 40.7% of the sampled small-scale desalination plants were using the chlorine for water disinfection whereas the other plants don't use any kind of disinfection methods. The *E. coli* O157 was detected in 20% of 152 groundwater samples which was attributable primarily to infiltration of sewage into the underground aquifer (Sharif, 2003).

The rural areas in the Gaza Strip are suffering from severe water contamination, demonstrating the widespread communicable diseases, especially among children (Al Khatib et al., 2015). Sadallah & Al-Najar (2015) study revealed that chlorine residual concentration in 220 out of 324 water samples collected from municipal water network in Um Al Nasser village was less than the WHO's recommended concentration (0.2 mg/l).

The case was not better for bottled water where fifteen bottled water brands available in the Gaza strip markets were microbiologically tested. The findings showed that 75% and 45.4% of locally produced and imported bottled water samples were contaminated with total coliforms, respectively. While 75% and 27% of locally produced and imported bottled water samples were contaminated with thermos-tolerant coliforms, respectively (Bashir & Aish, 2011). The question arises that any contamination might have occurred during the sampling process. However, all the studies claimed that their sampling and analysis were according to standard procedures which nullify this question.

## 4. Health Impacts of Bacteriological Contamination of Water in Gaza Strip

In spite of Palestinian water law grantees citizens' right to have access to safe water (Assaf et al., 2004). Nonetheless, over here, the foregoing studies prove beyond any doubt the likely incidence of water-borne diseases among Gaza's population. A few studies have given attention to water-borne diseases to achieve crucial evidence in terms of their burden on public health (Mourad, 2004; Elamreen et al., 2007). Significant association found between the prevalence of diarrheal diseases and lack of clean drinking water tank in 1625 households at Al-Nuseirat Refugee Camp at the Middle zone of Gaza strip (Mourad, 2004). Additionally, water-borne diseases such as Giardia Lamblia, Ascarislumbricoides, and Entamoeba histolytic have been reported in Gaza strip's children (Al-Wahaidi, 1997; Yassin et al., 1999; Al-Hindi, 2009). A cross-sectional study was conducted in Al Shuka village at Rafah governorate by Al Khatib et al. (2015) to identify the prevalence of waterborne diseases among the residents. The outcomes showed that 34.6% of study participants have suffered from diarrhea two weeks prior proceeding the survey, 68.1% out of them were children less than five years and, 22.2% were adult women, and 9.7% were adult men. The case-control study carried out among 113 diarrheal cases and 113 controls free from diarrhea to find the association between the incidence of diarrhea and drinking water source. Results of stool analysis showed that 5.5% and 20% of stools samples were infected with bacteria and giardia duodenitis, respectively. Likewise, drinking of non-improved municipal water was a risk factor for diarrhea with (OR: 0.046; 95% CI: 0.005 - 0.454; P = 0.0083) (Abouteir et al., 2011). The likelihood of getting waterborne diseases among Gaza strips' citizens drink non-improved municipal water was 1.6 times higher than those who drink improved desalinated water and strong correlation between fecal coliforms and giardiasis water pathogens (r = 0.7) were found by (Yassin et al., 2006).

Water-borne diseases such as diarrhea, Methemoglobinemia, and dental fluorosis are well-known and highly recorded in Gaza strip primary health care clinics. Therefore, the availability of alternative water resources is urgently needed to safeguard human health (Shomar, 2011a). The increased occurrence of water-washed diseases as trachoma in Gaza strip was found to be statistically significantly correlated with the interruption of water supply (Chumbley & Thomson, 1988; Sarsour & Al Shaarawi, 2013).

## 5. Causes and Sources of Microbiological Contamination of Water in Gaza Strip

The main united anthropogenic causes and exacerbate the microbiological contamination of Gaza strip's waters can be summarized as the (Israeli)-Palestinian conflict, the over-extraction of groundwater, the general rundown of the infrastructure and water distribution networks in particular, the spread of more than 100,000 cesspools with depth ranged between 8 to 12 m and typical diameter is 2 meters, widespread septic tanks, the excessive use of pesticides and fertilizers in agriculture, infiltrate of solid waste landfills leachate landfills into groundwater and improper treatment and disposal of wastewater (Awartani, 1994; Yassin et al., 2006; Almasri, 2008; Almasri & Ghabayen, 2008; Yassin et al., 2008; Afifi et al., 2015). On the other hand, the geographical location in an arid and semi-arid area, soil-water interaction in unsaturated zone due to recharge and return flows, and mobilization of deep brines and seawater intrusion all also natural factors contributed to a substantial deterioration of water quality in the Gaza strip (Ghabayen et al., 2006).

The power outage is a major problem that influences the performance of wastewater treatment plants and water desalination plants. About 70% of Gaza's wastewater disposed into the sea, 25% infiltrates into the aquifer and only 5% used in the agricultural fields for irrigation purposes after partial treatment (Al-Agha & Mortaja, 2005; Hamdan et al., 2008; Shomar et al., 2010b; Abd Rabou, 2011). Besides, Wadi Gaza transfers the raw sewage from the Middle zone's neighborhoods directly without any kind of treatment into the Mediterranean Sea producing pollution to groundwater and marine life (Shomar et al., 2005). Furthermore, several studies underlined the heavy microbial contamination of recreational seawater along the seashore of Gaza strip (Afifi et al., 2000; Elmanama et al., 2005; Weinthal et al., 2005; Ashour et al., 2009; Abualtayef et al., 2014).

The vast majority of Gaza's people still depend on the desalinated water transported by tanker trucks for drinking purpose. Unfortunately, less than half of small-scale desalination plants are licensed and subject to regular monitoring by the ministry of health. In addition, disinfection of drinking water in Gaza strip in most of the cases is not adequate and most of the population do not like chlorine taste in water which increases the odds of biofilm bacteria growth (Roeder et al., 2010; Aish, 2011; Mogheir et al., 2013).

## 6. The Impact of Political Conflicts on the Water Sector in the Gaza Strip

As stated above, groundwater in the Gaza strip is the only water source for domestic, agricultural, and industrial purposes. It is noteworthy that the abstraction rate of groundwater is greater than nature's ability to renew the aquifer since about 180 million cubic meters are abstracted every year, whereas just 55 - 60 million cubic meters are re-injected to the aquifer by rainwater. Hence, the over-abstraction of the groundwater has led to a deficit in recompense of 67% of total abstracted water annually (Baalousha, 2005; Selby & Hoffmann, 2012; PWA, 2013).

(Israel) and Gaza strip share the same aquifer, herein lies the reason for (Israeli)-Palestinian crisis with regard to the water sector. (Israel) imposed some restrictions for Palestinians in Gaza strip concerning the construction of water wells, particularly after (Israel) withdrew from Gaza in 2005. The (Israeli) blockade and siege on Gaza result in preventing the import of basic necessities for water and wastewater infrastructure development. Moreover, most of the water facilities infrastructure and disinfectants were vandalized during the (Israeli) attacks which led to immensely negative consequences on water sector (Feitelson & Rosenthal, 2012; Selby & Hoffmann, 2012; Chomsky & Papp, 2013).

The codification of water sector damages during the (Israeli) aggression on the Gaza strip at the end of 2008, subsequently, 11 water wells, 4 water reservoirs, 5200 households roof tanks, 19,920 m of municipal water pipes and 2445 m of sewage pipe networks were vandalized. In addition, the destruction of power lines has led to turning off the water supply to households as well as wastewater pumping stations. Such poor humanitarian situations have lasted for several years for the rehabilitation of what was devastated (Ashour et al., 2009; PHG, 2009).

It is noteworthy that various environmental development programs and initiatives have been put on hold because of restrictions that were imposed on Gaza following the Hamas movement election victory in 2006. The water sector accounted for the bulk of adverse impacts, as all of development projects and funds have been suspended by donors owing to security concerns (Shomar, 2011a).

Although the (Israeli)-Palestinian conflict seems long-standing and intractable gory, nonetheless of the view that there are many opportunities for cooperation which would serve the interests of both parties towards ecological integrity and environmental peacemaking (Chenoweth & Wehrmeyer, 2006).

Apparently, the application of quantitative microbial risk assessment (QMRA) is required in Gaza strip to estimate the risk level of pathogens and for the characterization of complex exposure pathways along the water chain and to support management decisions for the reduction of the burden of water-borne diseases.

## 7. Conclusions and Review Recommendations

In the Gaza strip, the levels of water contaminations have frequently exceeded the WHO's guidelines since high levels of total coliforms, fecal coliforms, and other pathogens such as *E. coli*, streptococcus, and pseudomonas have been detected in the Gaza's water supply system from catchment to consumer's tap. Latest reports of both UNRWA and MOH revealed that diarrheal diseases are the most important causes of childhood morbidity. Furthermore, an increased trend of the prevalence rate of diarrhea over the previous year in the Gaza strip has been noted. Gaza strip's waters are becoming over the years more and more scarce and polluted. (Israeli)-Palestinian conflict, a general rundown of the infrastructure and water distribution networks, in particular, the spread of cesspools, excessive use of pesticides and fertilizers, and improper treatment and disposal of wastewater remain major contributing to making Gaza strip the worst-case scenario in term of water problems. Moreover, the incidence of waterborne diseases among the population of the Gaza strip has not been given sufficient attention by previous studies. Therefore, a quantitative microbial risk assessment to estimate the diseases' burden attributable to consumption of low-quality water is urgently needed to safeguard public health from the prevalence of waterborne diseases and to avoid any further worsening of water resources in the Gaza strip.

The following recommendations were proposed to help researchers, stakeholders, and decision makers in the fields of water resources management and public health:

1) Construction of large-scale seawater desalination plants in the Gaza strip.

2) Development and maintenance of sewerage systems to avoid cross-contamination with municipality water supply networks.

3) Periodic monitoring of the drinking water distribution system from catchment to the consumer's tap according to the water safety plan as well as strict implementation of environmental and water resources protection laws.

4) Launch awareness campaigns to address harmful traditional practices that adversely affect water quality.

5) Actively exploring possibilities of strengthening cooperation between (Israel) and the Palestinian Authority with regard to the water management field.

6) Seeking new donors and convincing them to provide all the resources required to address water sector challenges.

7) Providing guidance and support to researchers in order to investigate the burden of waterborne diseases.

8) Continuing to search for alternative, unconventional and environmentally friendly water resources.

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## Conflicts of Interest

The authors declare that there is no conflict of interests.

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