Investigation of drinking water quality in the kindergartens of Gaza Strip Governorates

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Abstract

The aim of this study is to investigate drinking water contamination and to identify potential sources of contamination during the water production, delivery process and in water tanks in the kindergartens of Gaza Strip governorates. The samples were taken from water tanks in the kindergartens, water tankers and private desalination facilities in the Gaza Strip and analyzed for chemical and biological investigations. With reference to chemical investigations pH in the desalination plants was mostly below the acceptable level, with an average of 6.26. Conductivity, chloride, calcium and nitrate concentration levels were found to be in agreement with WHO and Palestinian standards whereas fluoride concentrations were found to be lower than WHO and Palestinian standards. Biological contamination in kindergartens water tanks is relatively higher than those detected in water tankers and private desalination facilities. There was no biological contamination in the private desalination plants of North, Gaza, Middle and Rafah governorates. The biological contamination only found in the samples collected from Khanyounis desalination plants with contamination percentage of total coliform (75%) and fecal coliform (66.66%). The contamination of drinking water in the kindergarten tanks and water tankers were due to the unsafe storage system. Water transportation appears to be only one of the potential causes of final contamination.

Keywords: Investigation, drinking water quality; contamination; kindergartens; Gaza Strip.

1- Introduction

The Gaza Strip has very limited water resources. Groundwater is the main source for domestic, industrial and agricultural purposes. Water resources are deteriorating in terms of quantities and quality which led to the establishment of commercial small-scale desalination plants to treat brackish water and distribute desalinated water by trucks for most of the Gaza Strip areas (UNNC, 2010). The groundwater in the Gaza Strip aquifer is approximately brackish excluding some fresh water in the appearance of shallow lenses. Consequently, the quantity of fresh groundwater is negligible and subsists only in some areas in the Gaza Strip for example Bait Lahia. The securing of potable water for drinking purpose to the community in the Gaza Strip is becoming an important goal to be implemented by the Palestinian Water Authority (El Sheikh et al., 2003). The quality of domestic water had been approximately totally deteriorated. The Palestinian Water Authority (PWA) identifies water desalination as the standard approach to alleviate the water problem and provide people in the Gaza Strip with acceptable and potable

water quality for drinking and other purposes (PWA, 2007).

The first desalination reverse osmosis (RO) plant in the Gaza Strip was built in 1991 at the center of Deir El-Balah with a capacity of 45 m^3/h by the EMS, a subsidiary of the Israeli (Mekorot) water company (EL Sheikh et al., 2003). Later, many large and small scale desalination plants were built and functioned to provide drinkable water for the population of the Gaza Strip who has limited water resources and depends generally on groundwater, where the salinity degrees mostly are high TDS (2,200 mg/l) and sometime above this value (Abu-Habib et al., 2012). According to (Al-Agha et al., 2005) in the past two decades 6 brackish water facilities and one seawater desalination plant were established in the Gaza Strip. The product desalinated water from these plants represents nearly 4% of the total water consumption by the population. More than 90% of this population depends on the desalinated water for drinking purpose (Mogheir et al., 2013). In addition, a number of small private RO desalination facilities are constructed and operated in all governorates of the Gaza Strip. Almost, there are seven public desalination plants situated all over the Gaza Strip operated by the Coastal Municipal Water Utilities (CMWU), the operational water body in the Gaza Strip (CMWU, 2009). These plants provide drinking water for the population in the middle and southern parts of the Gaza Strip. All of them are brackish water desalination plants except for one seawater RO plant located in the middle area of the Gaza Strip. The public plants have shown better performance and more significance when compared with small private plants. In addition, these plants are linked directly to the municipal water networks while private plants have distribution tanks and collecting points where people have to collect the water on their own. It was reported by (PWA) that more than 80 small RO private plants and stations are functioning and providing clean drinking water for the residents of the Gaza Strip at acceptable cost. Though, only 37 of these plants are registered and conduct regular monitoring as recommended by PWA (Mogheir et al., 2013). Several studies have documented the detection of chemical and biological contamination in the drinking water (Yasin et al., 2015, Al Moosa et al., 2015, Vyas et al., 2015). Meride and Ayenew (2016) assessed the water quality and its effect on residents in Wondo genet Campus, Ethiopia. The study concluded that all the water sampling sites were consistent with WHO standard for drinking water.

The Gaza Strip residents use ground water wells as main source of water which suffers from deterioration of the quality. Treated drinking water is provided by desalination plants which should enhance the quality of all water properties (Baalousha, 2006). It is recommended that the desalinated drinking water quality shall be investigated, and possible measures to reduce the environmental impacts on community health particularly children shall be introduced. Hence, for this purpose and for the first time this study is made to test if there is any chemical and microbiological influence on drinking water quality in the kindergartens of the Gaza Strip and to determine the source of contamination if present.

2- Materials and methods

2.1- Study area

The Gaza Strip is a narrow strip of land on the eastern coast of the Mediterranean sea, situated in the middle east at latitudes [31°16" and 31°45"N] and longitudes [34°20" and 34°25"E] bordered by the Mediterranean sea in the west and the Negev desert and Egyptian Sinai headland in the south with a total area of 365 Km^2 (Aish, 2004). Landscape of the Gaza Strip is essentially a foreshore plain. Gaza's water resources are essentially limited to that part of the coastal aquifer that underlies its area (Al-Talmas and Mogheir, 2012). Approximately

4.62 million Palestinians live in the West Bank and Gaza Strip, of whom about 1.79 million reside in the Gaza Strip (PCBS, 2014). In this work the kindergartens in Gaza Strip governorates are selected as study area. A total number of 50 kindergartens were selected, 7 from Northern area, 15 from Gaza city, 11 from Middle Area, 11from Khanyounis governorate and 6 from Rafah city. They are distributed as shown in Figure 1. Water samples were taken from 50 storage water tanks in the kindergartens, 43 trucks providing water to the kindergartens and 30 desalination plants supplying water to the selected kindergartens.

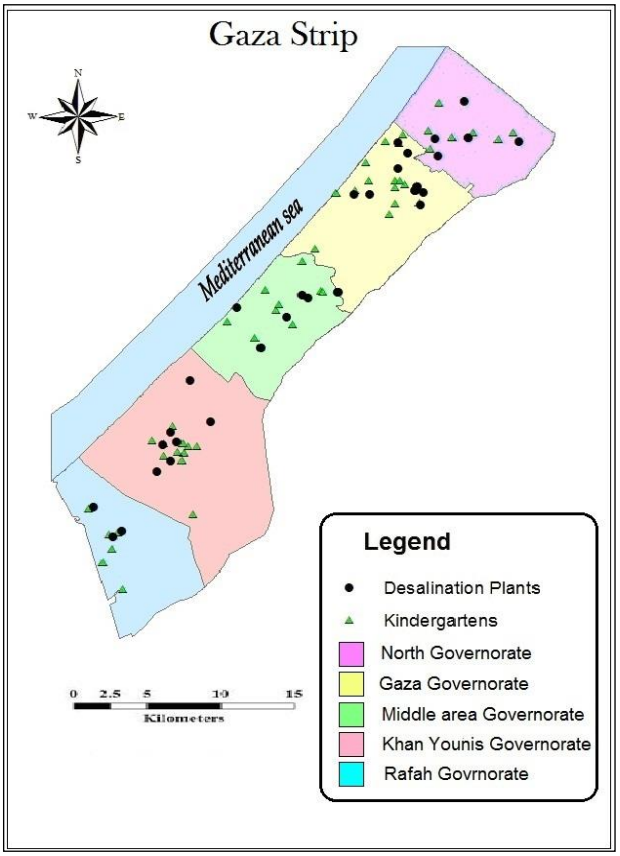

Figure 1) Map shows sampling sites of the study area

2.2- Collection and analyses of water samples

Water samples collection were conducted during September and December 2013. Sampling was performed according to Standard Methods for the Examination of Water and Wastewater 20th edition (APHA, 1999). Plastic bottles of one liter capacity were used to collect water samples for chemical examinations. Nonreactive borosilicate bottles of 300ml capacity were used to collect water samples for microbiological (Total Coliform TC and Fecal Coliform FC) tests. Before taking water samples all bottles were cleaned and rinsed carefully, given a final rinse with deionized or distilled water, and sterilized. For microbiological test a sufficient amount of sodium thiosulfate ($Na_2S_2O_3$) was added to all sampling bottles intended for the collection of desalinated water to eliminate residual chlorine toxic influences which may kill coliforms. All collected samples were delivered in icebox to the laboratory immediately and then kept in the refrigerator at 40ºC for 20 hours then analysis was done. The water samples were analyzed in the Palestinian Ministry of Health laboratories, Gaza. Chemical analyses were performed for major ions content using standard methods (APHA, 1999).The pH and electrical conductivity were measured directly in the field using a portable instrument known as Electrochemistry made by CIBA-CORNING. Nitrate was determined by a cadmium reduction method, followed by spectrophotometric measurement at 220nm wavelength. Hardness, calcium and magnesium were determined with EDTA titration method, while argentometric method was used to determine chloride. The method used to measure fluoride concentration in the water samples called SPANDS Spectrophotometric. Bacteriological analyses of water samples were analyzed for total coliform and fecal coliform in duplicate samples which were enumerated by the membrane filter method using m-FC agar (APHA 1999).

2.3- Data statistical analyses

Data analyses were performed by using the Statistical Package for Social Sciences (SPSS), and descriptive statistics (min, max, average, standard deviation, percentage) were used to describe the main features of the data. In addition the Pearson correlation coefficient (a measure of linear association) and paired sample t-test are used to study the relation

between various environmental parameters and detect significant variations among biological parameters in different demographic areas to determine the sources of contamination.

3- Results and discussion

3.1- Statistical analyses of drinking water quality data

Drinking water is a potential source of human exposure to a variety of contaminants, which are microbiological, chemical or radiological (WHO, 2006). The drinking water samples collected during this study were analyzed for chemical and bacteriological qualities. In this study an application of some useful statistical tools were used to investigate the quality of drinking water at the kindergartens storage tanks, water tankers and desalination plants in the Gaza Strip governorates and to determine the source of contamination. The results obtained from statistical analysis are given in Table 1.

Table 1) Water quality tested parameters of kindergartens, tankers and desalination units in Gaza Strip

Parameters	pH	EC μS/cm	TDS mg/l	Cl^- mg/l	Hardness mg/l	NO_3^- mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	F^- mg/l	TC CFU	FC CFU
Kindergartens											
Min	5.62	43	27.2	10	4.02	0.00	0.82	o.48	0.00	0.00	0.00
Max	8.69	403	249	90	60.25	79.8	13.12	7.27	0.25	100	100
Average	6.79	157	97.4	35.6	21.47	19.9	2.62	3.57	0.07	22	11
SD	0.63	74.8	49.5	20.8	12.18	16.7	2.43	2.02	0.07	37	26
Water tankers											
Min	5.48	44	27.4	10	4.02	0.00	0.46	0.48	0.00	0.00	0.00
Max	8.40	389	241	87.9	58.3	54.8	10.6	9.92	0.30	100	100
Average	6.50	151	93.8	32	19.8	20.9	2.05	3.58	0.08	7	3
SD	0.69	75.6	46.8	17.8	11.3	14.2	2.23	1.95	0.08	21	15
Desalination plants											
Min	5.22	45.5	28.2	10	4.02	0.00	0.08	0.48	0.00	0.00	0.00
Max	8.69	395	249	88.5	40.9	58.5	6.56	8.45	0.27	100	30
Average	6.26	158	98.3	33.3	21.14	33.3	2.16	3.82	0.08	4	1
SD	0.66	83.4	51.7	19.3	10.39	19.4	1.90	2.08	0.07	18	6
WHO	(6.5-8.5)	(1500)	(1000)	(250)	(500)	(45)	(100)	(60)	(1.5)	(0.0)	(0.0)
Palestinian Standard	(6.5-9.5)	(1500)	(1000)	(600)	(600)	(70)	(200)	(150)	(1.5)	(0.0)	(0.0)

3.2- Chemical quality of drinking water samples

There is a slight variation in pH level among the kindergartens in Gaza governorates, but the variation in pH values is higher between kindergartens and desalination units. The values of pH in water samples taken from kindergartens water tanks were ranging from 5.58 to 8.69 with an average value of 6.79. About 82% of pH values of samples collected from kindergartens meeting with the World Health Organization and Palestinian standards (PS). The values of pH in samples taken from tankers which used to supply water to kindergartens in Gaza Strip were ranging from 5.62 to 8.40 with an average of 6.50. About 47% of pH values in the samples collected from trucks found to be in agreement with the WHO and PS. The values of pH in water samples taken from all desalination facilities storage tanks were ranging from 5.22 to 8.69 with an average of 6.26. About 22% of pH values in the water samples collected from desalination units found to be in agreement with the WHO and PS. It is clear that most of pH values in water samples were less than WHO and PS standards as a result of lacking in pH adjustment and absent of quality control in desalination plants. The values of EC in samples collected from kindergartens storage water tanks ranging from 43.90 to 403μS/cm with an average value of 157.18μS/cm. The values of EC in samples taken from water trucks were ranging from 44.30 to 389μS/cm with an average of 151.34 μS/cm. The values of EC in water samples collected from desalination units were ranging from 45.5 to 395 μS/cm with an average of 158.54μS/cm. All the values of EC in the water

samples collected from kindergartens, trucks and desalination units found to be lower than WHO and PS. The values of TDS in samples taken from kindergartens storage water tanks ranged between 27.22 and 249.86 mg/l with an average value of 97.45 mg/l. The concentrations of TDS in samples collected from water tankers were ranging from 27.47 to 241.18 mg/l with an average of 93.82 mg/l. The levels of TDS concentration in water samples taken from desalination facilities were ranging from 28.21 to 244.90 with an average of 98.29 mg/l. All water samples were found to be lower than the allowed concentration level according to WHO and PS Palestinian standard. Continuous consumption of water with high TDS content can cause gastro-intestinal irritation. It also causes undesirable taste and corrosion or incrustation (WHO, 2003). Generally there is a big gap between feed and product water concentrations of TDS as a result of high removal efficiency performed by desalination facilities in the Gaza Strip. The values of hardness in samples were taken from kindergartens storage water tanks ranging from 4.02 to 60.25 mg/l with an average value of 21.47 mg/l. The values of hardness in water samples collected from water trucks were ranging from 4.02 to 58.29 mg/l with an average of 19.87 mg/l. The hardness levels in water samples collected from desalination units were ranging from 4.02 to 40.97 mg/l with an average of 21.14 mg/l. All the values of hardness in the water samples collected from kindergartens, water tankers and desalination units found to be about 7 times lower than WHO and PS level. The chloride concentrations in samples taken from kindergartens water storage tanks ranged between 10 and 90.30 mg/l with an average concentration of 35.63 mg/l. The concentrations of Cl- in samples taken from water tankers were ranging from 10 to 87.91 mg/l with an average of 32.03 mg/l. The levels of Cl- concentration in water samples taken from desalination facilities were ranging from 10 to 88.53 mg/l with an average of 33.34 mg/l. All water samples were found to be lower than the allowed concentration level as compared with WHO and PS.

There is a slight variation in the nitrates concentration of water samples taken from kindergartens, trucks and desalination. The nitrate concentrations in samples taken from kindergartens water storage tanks ranged between 0 and 79.89 mg/l with an average concentration of 19.97 mg/l. The nitrate concentrations in water samples taken from tankers were ranging from 0 to 54.34 mg/l with an average of 20.44 mg/l. The nitrate levels in water samples collected from desalination units were ranging from 0 to 58.30 mg/l with an average of 18.93 mg/l. It was found that most of water samples have lower and allowable concentration levels of nitrates when compared with WHO and PS (50 mg/l) except for few samples which were taken from both Rafah and Khanyounis governorates. This is maybe due to anthropogenic source which increased the amount of nitrate to harmful level especially from sites used for disposal of human sewage and septic tanks which represent a major local source of nitrate contamination of ground water especially in Khanyounis area of Gaza Strip. Significant removal of nitrates could be found in the desalination plants existing in North and Middle Area governorates.

The level of calcium concentrations in water samples taken from kindergartens storage tanks ranged between 0.82 and 13.12 mg/l with an average concentration of 2.62 mg/l. Ca^{++} concentrations levels in water samples taken from tankers were ranging from 0.46 to 10.66 mg/l with an average of 2.05 mg/l. Calcium levels in water samples collected from desalination units were ranging from 0.08 to 6.56 mg/l with an average of 2.16 mg/l. All investigated water samples have lower concentration levels of calcium than WHO and PS. Calcium is an essential of the human diet. But the nutritional value from water is likely to be minimal as compared to that from other food

sources. There is no health objection to high calcium content, the main limitations being made on the grounds of excessive scale formation. In the Gaza Strip all private desalination plants and in the absence of quality control, mostly desalinated water has negligible amounts of several minerals such as calcium. It is reported that the permeate water of these plants has less than 30 mg/l Ca^{++} and similarly other elements. Therefore, the permeate water contains no elements that are needed for human health. However, Calcium is very important element for human growth mainly babies .The lack of calcium in human bodies may cause osteoporosis (Mahadevan et al., 2012). The levels of magnesium concentration in the water samples taken from kindergartens tanks ranged between 0.48 and 7.27 mg/l with an average concentration of 3.57 mg/l. The levels of magnesium content in water samples taken from tankers were ranging from 0.48 to 9.92 mg/l with an average of 3.58 mg/l. Mg++ levels in water samples taken from desalination units were ranging from 0.48 to 8.45 mg/l with an average of 3.82 mg/l. All investigated water samples have lower magnesium concentrations than what is allowed by WHO and PS. Because of the lowest values of calcium and magnesium in drinking water delivered to the kindergartens premises in the Gaza Strip it is recommended to study the effects of minerals deficiencies on children health.

The levels of fluoride in water samples taken from kindergartens tanks ranged between 0 and 0.25 mg/l with an average concentration of 0.07 mg/l. The levels of fluoride in water samples taken from tankers were ranging from 0 to 0.30 mg/l with an average of 0.08 mg/l. Fluoride levels in water samples taken from desalination plants were ranging from 0 to 0.27 mg/l with an average of 0.08 mg/l. All concentration levels of fluoride in water samples were found to be lower than allowable levels according to WHO and PS. According to WHO (1996) low fluoride intake is considered to be a potential factor with care to the loss of fluoride from the bones. The optimum fluoride concentration in drinking water for dental health is mostly between 1.0 and 1.5 mg/l and being contingent on the amount of drinking water used up as well as drinking and revelation from other sources (Aish, 2013).

3.3- Microbiological tests of drinking water quality

Total coliform and fecal coliform analyses of 50 water samples were conducted from drinking water storage tanks at the kindergartens in the Gaza Strip governorates. Very consistent levels of contamination were found reaching an average of 60% of total coliform contamination with 13 samples revealing low levels of contamination (less than 10 colonies per 100 ml), 6 samples revealing medium levels of contamination (between 11 and 50 colonies per 100 ml) and 11 samples revealing high level of contamination (more than 50 colonies per 100 ml). Consistent levels of contamination were found reaching an average of 40% of fecal coliform contamination with 10 samples illuminating low levels of contamination, 5 samples illuminating medium levels of contamination and 4 samples illuminating high level of contamination. The high level of contamination may be due to the unsafe storage water tanks system. Biological analyses of 43 water samples were conducted from water tankers distributing water to kindergartens in the Gaza Strip governorates. Very stable levels of contamination were found reaching an average of 33% of total coliform contamination with 27 samples revealing no contamination, 10 samples revealing low levels of contamination 4 samples revealing medium level of contamination and 2 samples revealing high level of contamination. Low level of contamination was found reaching an average of 28% of fecal coliform contamination with 31 samples illuminating no contamination, 9 samples illuminating low levels of contamination, 2 samples illuminating medium level of contamination and one sample

illuminating high level of contamination. Biological analyses of 30 water samples were conducted from private desalination plants used to supply drinking water to kindergartens in the Gaza Strip governorates. Very low level of contamination was found reaching an average of 20% of total coliform contamination with 24 samples revealing no contamination, 4 samples revealing low levels of contamination, one sample revealing medium level of contamination and one sample revealing high level of contamination. Very low level of contamination was found reaching an average of 13% of fecal coliform contamination with 26 samples illuminating no contamination, 2 samples illuminating very low levels of contamination, 2 sample illuminating medium level of contamination. The highest and only level of total coliform and fecal coliform contamination was detected in the water samples taken from Khanyounis private desalination plant (Al-Salafea). This is may be due to the contamination of feeding groundwater well with bacteriological sources or due to the low efficiency of RO desalination unit system in removing bacteria from water.

3.4- Linear correlation coefficients of collected water sample variables

Table 2 shows the results of correlation coefficients between various water samples parameters taken from kindergartens storage water tanks, water tankers and private desalination units in the Gaza Strip governorates. From Table 2 it can be seen that nitrate is correlated positively with chloride, calcium, fluoride, TC and FC. TDS is correlated positively with pH, EC, NO^{3-}, chloride, calcium, FC and TC. Chloride is inversely correlated with magnesium and positively with temperature, EC, TDS, FC and TC.

Table 2) Correlation coefficients among various water quality parameters

Parameters	pH	EC	TDS	Cl^-	Hardness	NO_3^-	Ca^{2+}	Mg^{2+}	F^-	TC	FC
pH	1.00										
EC	0.12	1.00									
TDS	0.12	1.00	1.00								
Cl^-	0.00	0.90	0.90	1.00							
Hardness	0.28	0.09	0.09	-0.05	1.00						
NO_3^-	-0.05	0.49	0.49	0.27	0.00	1.00					
Ca^{2+}	0.38	0.19	0.19	0.03	0.72	0.15	1.00				
Mg^{2+}	0.13	-0.01	-0.01	-0.10	0.86	-0.09	0.27	1.00			
F^-	-0.02	0.08	0.08	0.03	-0.02	0.24	0.11	-0.10	1.00		
TC	0.23	0.27	0.27	0.16	0.11	0.30	0.24	-0.02	0.29	1.00	
FC	0.12	0.19	0.19	0.11	0.11	0.21	0.18	0.03	0.09	0.74	1.00

Fluoride is inversely correlated with magnesium and positively with nitrate, calcium and TC. Total coliform is positively correlated with pH, EC, nitrate, TDS, chloride and calcium. Fecal coliform is positively correlated with total coliform, TDS, EC, nitrate and calcium. Electrical conductivity is found to be strongly correlated with chloride and TDS. Nitrates found to be moderately correlated with EC and TDS. Calcium is found to be strongly correlated with hardness and moderately with pH. Magnesium is observed to be strongly correlated with hardness. Fluoride is noticed to be between weak and moderate correlation with NO^{3-} and calcium. Total coliform is found to be moderately correlated with NO^{3-} and EC as well as strongly with FC.

3.5- Comparison of bacteriological contamination

The comparison between bacteriological contamination of drinking water among samples taken from kindergartens water tanks, water tankers supplying water to kindergartens and desalination RO facilities are given in Table 3. The results presented in the above table shows that the bacteriological contamination of water with total coliform is higher than the

contamination with fecal coliform. Results also show that the bacterial contamination in water samples taken from kindergartens water tanks is relatively higher than those detected in samples collected from water tankers and desalination facilities outlet. The degree of total coliform and fecal coliform contamination among the analyzed water samples in the Gaza Strip follows the order kindergartens>water tankers>desalination units as shown in Table 3.

Table 3) Bacteriological contamination of collected water samples

Parameters/Source	Water samples No.	Contaminated samples No.	Contamination %
Total Coliform			
Kindergartens	50	30	60%
Water tankers	43	16	37%
Desalination units	30	6	20%
Fecal Coliform			
Kindergartens	50	20	40%
Water tankers	43	12	28%
Desalination units	30	4	13%

3.6- Determination of contamination source

The contamination point source was identified by using several methods, but in this study bacteriological association between living area and contamination of water quality in the Gaza Strip was used. These were made by using statistical tools including: paired t-test (p-value) and T-value. Also the number of contaminated samples as well as percentage was calculated among kindergartens, water tankers and private desalination plants storage tanks. These were used to check which place of desalinated drinking water (plant, trucks and kindergartens tanks) is responsible of being source of contamination (Table 4 and 5).

Table 4) Statistical analysis demonstrates contamination percentage of TC among water samples of kindergartens, water tankers and desalination plants in the Gaza Strip governorates.

Governorate	Parameters				
	Contamination				Result
	Yes		No		
	N	(%)	N	(%)	
North	Total Coliform				
Kindergartens	3	42.86	4	57.14	Contaminated
Water tankers	0	0	5	100	Not contaminated
Desalination plants	0	0	5	100	Not contaminated
Gaza	Total Coliform				
Kindergartens	7	44.66	8	53.33	Contaminated
Water tankers	3	23.07	10	76.92	Contaminated
Desalination plants	0	0	9	100	Not contaminated
Middle	Total Coliform				
Kindergartens	4	26.66	7	63.36	Contaminated
Water tankers	1	10	9	90	Contaminated
Desalination plants	0	0	6	100	Not contaminated
Khanyounis	Total Coliform				
Kindergartens	10	90.90	1	9.09	Contaminated
Water tankers	8	88.88	1	11.11	Contaminated
Desalination plants	6	75	2	25	Contaminated
Rafah	Total Coliform				
Kindergartens	5	83.33	1	16.66	Contaminated
Water tankers	4	66.66	2	33.33	Contaminated
Desalination plants	0	0	3	100	Not contaminated

It is clear from the results showed in Tables 4 & 5 that biological contamination level in water samples taken from kindergartens and water tankers was higher in Khanyounis and Rafah

governorates when compared with North, Gaza and Middle Area governorates. The least biological contamination in kindergartens water tanks found to be in North and Middle Area governorates where the contamination percentage found to be (TC 42.86%, FC 14.28 %) and (TC 26.66%, FC 27.27%) respectively. The contamination level in the water tanks of kindergartens in Gaza governorate found to be moderate where TC and FC contamination percentage was (TC 44.6%, FC 33.33%) respectively. There was no bacteriological contamination in the water samples taken from desalination plants outlet of North, Gaza, Middle and Rafah governorates. The contamination was only found in the samples collected from Khanyounis desalination plants outlet with contamination percentage of (TC 75%, FC 66.66%). This high level of contamination may be because of bad biological quality of the groundwater ; bad quality of the filters used in the private desalination plants which play an important role in the formation of bacterial colonies inside the filter; most plants depend on ultraviolet radiation (UV) for water disinfection which are inactive against high levels of contamination; moreover, UV is unlike chlorine that leaves a remainder-free chlorine protects water from external source pollution; the unqualified workers operating these plants may be considered as another cause of contamination; continuous damage in the chlorination pumps which lead to un-chlorinated or non-disinfected water; noncompliance with health and environmental conditions and working without a license from the relevant authorities distorts the process of monitoring the quality of the product water. The biological contamination of drinking water in the Gaza Strip is not astonishing but is a lean-to a number of previous years, as reported by Ministry of Health (2011). It was reported that the biological contamination percentage of drinking water for the year 2011 was (16.8%), while in the year 2010 (23.1%).

Table 5) Statistical analysis demonstrates contamination percentage of FC among water samples of kindergartens, tankers and desalination plants in the Gaza Strip governorates

Governorate	**Parameters**				
	Contamination				**Result**
	Yes		**No**		
	N	**(%)**	**N**	**(%)**	
North	Fecal Coliform				
Kindergartens	1	14.28	6	85.71	Contaminated
Water tankers	0	0	5	100	Not contaminated
Desalination plants	0	0	5	100	Not contaminated
Gaza	Fecal Coliform				
Kindergartens	5	33.33	10	66.66	Contaminated
Water tankers	2	15.38	11	84.61	Contaminated
Desalination plants	0	0	9	100	Not contaminated
Middle	Fecal Coliform				
Kindergartens	3	27.27	8	72.72	Contaminated
Water tankers	1	10	9	90	Contaminated
Desalination plants	0	0	9	100	Not contaminated
Khanyounis	Fecal Coliform				
Kindergartens	6	54.54	5	45.45	Contaminated
Water tankers	6	66.66	3	33.33	Contaminated
Desalination plants	4	66.66	2	33.33	Contaminated
Rafah	Fecal Coliform				
Kindergartens	5	83.33	1	16.66	Contaminated
Water tankers	3	50	3	50	Contaminated
Desalination plants	0	0	3	100	Not contaminated

The results of bivariate paired t-test indicated that there are significant differences in the biological contamination levels in drinking water samples taken from kindergartens, tankers

and private desalination plants in the Gaza Strip governorates. These significance differences justify the determination of point source of biological contamination over the samples taken from kindergartens, tankers and desalination plants and prove that there is a real difference between the kindergartens chosen for the water quality assessment purpose. It is also observed that there is a high significant difference in contamination level in samples taken from kindergartens and tankers in North and Khanyounis governorates. Similar results were also noticed in the samples taken from kindergartens and water tankers in North and Rafah, Gaza and Khanyounis, Middle area and Khanyounis as well as Middle and Rafah. There was no significant difference in biological contamination in the samples taken from private desalination plants among all five governorates. These observations prove that contamination may come from unsafe hygiene process applied by the drivers while filling the tankers. May be water tankers drivers do not clean the tankers properly. Also may be during tanker filling the hose would touch the ground and safety process were not applied by those drivers while handling water to kindergartens water tanks. The p-value test proved that a desalination plant was not one of the sources causing contamination in the water tanks of Gaza Strip kindergartens.

4- Conclusion

A total of 123 water samples were collected from 50 kindergartens, 43 water tankers and 30 private desalination plants in the Gaza Strip and analyzed for the evaluation purpose of water quality with respect to product including: pH, EC, TDS, hardness, chloride, nitrate, magnesium and calcium. Results revealed that pH of water tested from private desalination plants was found below the WHO and Palestinian standards drinking water acceptability. From a quality point of view, electrical conductivity, hardness, chloride, calcium and nitrate concentration levels of all samples were found to be within WHO and PS drinking water standards whereas fluoride concentration levels were found to be lower than allowed by WHO and PS which required for dental health (1-1.5 mg/l).

Biological investigation results showed that the contamination in water samples taken from kindergartens water tanks relatively is higher than those detected in samples collected from water tankers and private desalination plants. The degree of total coliform and fecal coliform contamination among the analyzed water samples in the Gaza Strip follows the order kindergartens > water tankers > private desalination plants. There was no biological contamination in the water samples taken from desalination plants of North, Gaza, Middle and Rafah governorates. The contamination only found in the samples collected from Khanyounis desalination plants with contamination percentage of (TC 75%, FC 66.66%). The study showed that biological contamination of drinking water in kindergarten tanks and water tankers were the most significant source of contamination due to the unsafe storage system. Water transportation appears to be only one of the potential causes of final contamination in the kindergartens of Gaza Strip.

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