Microbiological Quality of Marketed Drinking Water in Gaza City

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Abstract: *Water shortage is one of the most serious problems in the world today. Gaza Strip is not excluded; it especially suffers from severe water shortage. Microbiological quality of water in Gaza Strip is dramatically poor. Therefore, this study aims to investigate the microbiological quality of the different types of marketed drinking water available in Gaza city. Study population consists of 20 samples collected from desalination plants, 12 samples collected from water vehicle tankers, 25 samples from water distribution points, and 12 samples from water locally bottled in Gaza. An experimental design has been used to verify water microbiological quality by using Membrane Filtration Technique for detection of both total and fecal coliforms , Pseudomonas aeruginosa, and fungi (molds and yeasts) respectively.*

The results indicate that there is contamination with total coliforms, fecal coliforms, Pseudomonas aeruginosa , yeasts and molds in samples collected from desalination plants, water vehicle tankers and water distribution points. The bottled water samples are free of total coliforms, fecal coliforms, yeasts and molds, meanwhile the bottled water samples after three months storing are free of fecal coliforms, yeasts and molds .

Keywords: *Drinking water, Gaza city, Microbial contamination, Coliform, Pseudomonas, Fungi.*

Introduction:

Water scarcity and insufficiency is becoming the main problem in the World. The ongoing draughts and the water increasing demands of the growing populations are the major factors that reduce the water natural reservoirs (Sazakli et al., 2007).

Gaza Strip is narrow district located at the Mediterranean Sea. It is 40 km long, and its width varies from 7 to 12 km. Its area is around 365 km^2. Its population is around 1.6 million and considered as one of the most populated areas in the world (4054/km2) (Palestine Central Bureau of Statistic, 2007).

Controlling and monitoring the quality (biological, physical and chemical) of the water wells and water distribution networks at Gaza Strip are not always permissible due to constrains forced by the Israeli occupation either on the entry of the disinfectants and instruments required for water quality assurance, or, sometimes, on reaching the wells that are located near the borders.

Recently, the Israeli war on Gaza 2008/2009 has been massively devastating. It resulted in heavy damages in the water sector, destruction of arable land and water pumps. This may caused contamination of the aquifer at several points.

The purpose of this study is to assess the microbiological quality (identify and determine diversity, occurrence and distribution) of the marketed drinking water in Gaza city. The study includes the safety of the marketed drinking water as compared to WHO and also determined the number and type of microorganisms present in water samples that include yeasts, molds, coliforms, fecal coliforms, and *Pseudomonas aeruginosa* .

Materials and methods

1. Study design

An experimental analytical design has been used with cross sectional method for data collection and water sampling for microbiological examination. In addition direct interviews have been conducted with the producers, distributors and sellers.

2. Study population

The population of this study includes desalination plant, the water distribution points and water distribution vehicle tankers in Gaza city as it supply drinking water market. Furthermore, it includes bottled drinking water produced in Gaza city. In the present study, water distribution points are referred to the local distribution tanks at the shops and supermarkets.

The study has been limited to the samples selected from desalination plant and bottled water factories in Gaza city.

3. Study duration

To assess water quality, this study lasted for three months (June to August 2010).

4. Ethical consideration

An approval letter has been obtained from Coastal Municipalities Water Utility.

5. Experimental and Laboratory Work

For desalinated water source, 3 samples of 500 ml each have been collected in triplets from the operative factory or station, the distribution containers, and the water distribution points. At each collection point, before sampling sterilization of the output end with direct flaming has been performed. All samples have been collected in sterilized containers. Each bottled water sample has been collected from producers or from the market place, with the same patch number in triplicates . The collected 500 ml samples at each station have been used to perform the microbiological examination.

Five hundred ml water samples have been collected for the isolation total coliforms by filtering through a 0.45 µm-pore size membrane filters (Schleicher & Schuell, Germany). Filters have been incubated in m Endo agar media at 37 ±1 C° for up to 48 hours. On fecal coliforms isolation, another 500 ml water samples have been used, then filtered through a 0.45 µm-pore size membrane filters. Filters have been incubated in m Endo agar medium at 44.5 ±1 C° for up to 48 hours (APHA., 1998).

Another five hundred ml water samples have been used for the heterotrophic bacterial count. The samples have been filtered and filters have been incubated on plate count agar medium at 37 ±1 C° for up to 48 hours. (TS 9308-1, 2004).

For the isolation molds five hundred ml of water samples have been collected then filtered, and filters have been incubated on Czapek's agar medium containing chloramphenicol in darkness at 20 ±1 C° for up to 2 weeks. The number of colonies has been determined (number of CFU / 100 ml).

For the isolation of *Pseudomonas aeruginosa* five hundred ml water samples have been collected then membrane filtered. Filters have been incubated in cetrimide agar media at 37 ±1 C° for up to 48 hours. (DS DS/EN 12780 Document Information, 2004).

6. Bacterial identification

Identification of the obtained bacteria has been based on the conventional taxonomy procedures as described in Bergey's manual of systematic bacteriology, in addition to using commercial identification Kits (API systems) to confirm the identification.

7. Fungi

Fungal isolates have been purified and investigated microscopically.

8. Data analysis

The Statistical Package for the Social Sciences (SPSS) version 11 has been used in data entry, statistical analysis and treatments and p-values less than 0.05 were considered statistically significant.

Results

The data of the present work have been collected through two procedures: a questionnaire and an experimental analysis. The questionnaire has provided data and information about the nature, origin, and operational system of the desalination plants, water vehicle tankers, and water distribution points. While, in the experimental part of this work, water samples have been collected and proper methodology and techniques for filtration of water samples and identification of the different microbiological contaminations have been followed.

1. Descriptive analysis of the different water containing systems

1.1 Desalinated drinking water

In the present work, 57 desalinated water samples were collected from water desalination system (Table 1).

About (90%) of the desalination plants use plastic tanks for storing the desalinated output water, while only 10 % use stainless steel containers for the same purpose.

Table (1): Types of Desalinated Drinking Water

Type of Water Source	No.	%
• Water stations	20	35%
• Water vehicle tankers	12	21%
• Water distribution points	25	44%

Total	57	100
Water Stations	No.	%
• Licensed	9	45%
• Unlicensed	11	55%
Total	20	100
Establishment Date	No.	%
• Less than one year	4	20%
• 1-5 years	13	65%
• More than 5 years	3	15%
Total	20	100
Stations Water Resources	No.	%
• Municipality wells	1	5%
• Private wells	17	85%
• Irrigation wells	1	5%
• Other	1	5%
Total	20	100
Stations Daily Production Capacity	No.	%
• 5-10 m3	2	10%
• 11-20 m3	6	30%
• More than 20 m3	12	60%
Total	20	100
Water Test before and after Production	No.	%
• Performed Outside Station	19	95%
• Non Performed	1	5%
Total	20	100
Water Reservoirs	No.	%
• Plastic	18	90%
• Stainless steel	2	10%
Total	20	100

1.2 Water Vehicle tankers

Table (2) showed that 12 (21%) samples were collected from water vehicle tankers in Gaza city. This amount includes (83.8%) sample water from specified stations. Eight of them (66.7%) don’t check on water hygiene and cleanness. Seven (58.3%) clean water tanks at unspecified time, and five (41.7%) never clean tanks. However, five of total samples (41.7%) use chlorine to disinfect water, and seven (58.3%) use other types of disinfectants.

Table (2): Water Vehicle Tankers

Plants to Provide Tanks Only	No.	%
• Yes	10	83.8%
• No	2	16.2%
Total	12	100
Check for Hygiene Quality	No.	%
• Yes	4	33.3%
• No	8	66.7%
Total	12	100
Frequency of Hygiene Check	No.	%
• Weekly	1	8.3%
• Monthly	2	16.7%
• Others	1	8.3%
• Not performed	8	66.3%
Total	12	100
Tank Cleaning	No.	%
• Performed	7	58.3%
• Not performed	5	41.7%
Total	12	100
Frequency of Tank Cleaning	No.	%
• No specified time	7	58.3%
• Never cleaning	5	41.1%
Total	12	100
Type of Disinfectant	No.	%
• Chlorine	5	41.1%
• Other chemicals	7	58.3%
Total	12	100
Tank Refill	No.	%
• Daily	6	50%
• When needed	6	50%
Total	12	100

1.3 Water distribution points

Twenty five samples (44%) were collected from different distribution points.

Table 3 shows that the most active water distribution points are made of stainless steel (92%) and 2 other samples were collected from plastic containers (8%). 4 samples (16%) have been checked for hygienic quality of its drinking water on monthly basis, but 21 samples (84%) have never checked for the hygienic quality of their drinking water. 96% of the distribution points (23 points) have been restricted for disinfection and cleaning as reported by the operators of the water distribution points. Most of them (52%) did check on regular check base, but 40% of them (10 points) did a check on a monthly basis.

Furthermore, table (3) indicates that 6 samples (24%) have used chlorine for water disinfection. 19 samples (76%) used other means of disinfection. About the location of the water distribution points and its exposure to sun light, 3 samples (12%) were protected from direct sunlight and 22 samples (88%) were not protected from direct sunlight as reported by the operators.

Table (3): Water Distribution Points Characteristics and Treatment

Type of Distribution Points Used for Storage	No.	%
• Plastic containers	2	8%
• Stainless steel containers	23	92%
Total	25	100
Distribution Points Hygienic Check	No.	%
• Total and partial check	4	16%
• No check	21	84%
Total	25	100
Period of Check for Hygiene Quality	No.	%
• Monthly	4	16%
• No check	21	84%
Total	25	100
Cleaning of Tanks	No.	%
• Yes	24	96%
• No	1	4%
Total	25	100
Cleaning Frequency (point)	No.	%
• Weekly	1	4%
• Monthly	10	40%
• Other	13	52%
• No cleaning	1	4%
Total	25	100
Type of Disinfectant	No.	%
• chlorine	6	24%

• Others	19	76%
Total	25	100
Tank Refill Frequency	No.	%
• Daily	1	4%
• Weekly	1	4%
• Occasionally or when needed	23	92%
Total	25	100
Location of Distribution Points	No.	%
• Protected from dust and sunlight	3	12%
• Non protected from dust and sunlight	22	88%
Total	25	100

2. Microbial Presence in Drinking Water

2.1 Microbial Contamination in Desalination Plant

Microbiological investigations of samples from desalination plants indicate that the most prevalent type of bacterial contamination is total coliforms. 12 samples (60%) were found to be contaminated with total coliforms ranging from (1-50 cfu/100ml) and only 8 samples were not contaminated.

Moreover, the results showed that 6 samples (30%) were contaminated with fecal coliforms ranging between (1-30 cfu/100ml); while 14 of the samples (70%) showed no contamination.

Nine samples (45%) out of 20 samples are contaminated with *P. aeruginosa* ranging between (1 -200 cfu/250ml). Meanwhile the results indicate that 5 samples (25%) are contaminated with molds ranging between (1-10 cfu/100ml); and 4 samples (20%) are contaminated with yeasts ranging between (1-50 cfu/100ml).

Table (4): Microbial Contamination in Desalination Plants:

Microbial Contamination		No. of stations	Percent %
Total coliform	Un contaminated	8	40%
	Contaminated	12	60%
	Total	20	100
Fecal coliform	Un contaminated	14	70%
	Contaminated	6	30%
	Total	20	100
	Un contaminated	11	55%

Pseudomonas aeruginosa	Contaminated	9	45%
	Total	20	100
Molds	Un contaminated	15	75%
	Contaminated	5	25%
	Total	20	100
Yeasts	Un contaminated	16	80%
	Contaminated	4	20%
	Total	20	100

2.2 Microbial Contamination in Water Vehicle tankers

It was revealed that 6 samples (50%) out of 12 samples are contaminated with total coliforms ranging between (1-20 cfu/100ml) in the water vehicle tankers. 5 samples (41.7%) out of 12 samples have been contaminated with fecal coliforms ranging between (1-10cfu/100ml).

Six samples (50%) out of 12 have been contaminated with *P. aeruginosa* ranging between (1-20 cfu/250ml); and 6 samples (50%) have been contaminated with yeasts ranging between (1-20cfu/100ml) in the water vehicle tankers.

However, 10 samples (83.3%) out of 12 samples have been contaminated with molds ranging between (1-15cfu/100ml).

Table (5): Microbial Contamination in Water Vehicle Tankers

Microbial Contamination		No. of vehicles	Percentage
Total Coliform	Un contaminated	6	50%
	Contaminated	6	50%
	Total	12	100
Fecal coliform	Un contaminated	7	58.3%
	Contaminated	5	41.7%
	Total	12	100
Pseudomonas aeruginosa	Un contaminated	6	50%
	Contaminated	6	50%
	Total	12	100
Molds	Un contaminated	2	16.7%
	Contaminated	10	83.3%
	Total	12	100
Yeasts	Un contaminated	6	50%
	Contaminated	6	50%
	Total	12	100

Fifteen samples (60%) out of 25 samples have been contaminated with total coliforms ranging between (1-50cfu/100ml) in the distribution points. 4 samples (16%) have been contaminated with fecal coliforms.

Twelve samples (48%) have been contaminated with *P. aeruginosa* ranging between (1-50cfu/250ml), 14 samples (56%) have been contaminated with molds ranging between (1-20cfu/100ml); and 4 samples (14%) have been contaminated with yeasts ranging between (1-15cfu/100ml).

Table (6): Microbial Contamination in Distribution Points

Microbial Contamination		No. of vends	Percent %
Total coliform	Un contaminated	10	40
	Contaminated	15	60
	Total	25	100
Fecal coliform	Un contaminated	21	84
	Contaminated	4	16
	Total	25	100
Pseudomonas aeruginosa	Un contaminated	13	52
	Contaminated	12	48
	Total	25	100
Molds	Un contaminated	11	44
	Contaminated	14	56
	Total	25	100
Yeasts	Un contaminated	21	84
	Contaminated	4	14
	Total	25	100

2.4 Microbial Contamination in Bottled water

All 12 samples that have been taken from the bottled water were proved to be free of total, fecal coliforms and yeasts. Four samples (33%) contain more than 100 CFU/ml total bacteria exceeding WHO standards that must be less than 100 CFU/ml.

However, one sample has been contaminated with *P. aeruginosa* (3 cfu/250ml) and 2 samples have been contaminated with molds (10 & 15cfu/100ml respectively).

Table (7): Microbial Contamination in Bottled Water

No.	Source of sample	TC	FC	TBC	Ps.a.	Molds	Yeasts
1.	Bottled water A (Room Temp.)	N	N	>100	N	N	N
2.	Bottled water A (Dark)	N	N	>100	N	N	N
3.	Bottled water A (Refrigerator)	N	N	>100	3	10	N
4.	Bottled water A (Sun)	N	N	N	N	N	N
5.	Bottled water B (Room Temp.)	N	N	10	N	N	N
6.	Bottled water B (Dark)	N	N	10	N	15	N
7.	Bottled water B (Refrigerator)	N	N	2	N	N	N
8.	Bottled water B (Sun)	N	N	>100	N	N	N
9.	Bottled water C (Room Temp.)	N	N	5	N	N	N
10.	Bottled water C (Dark)	N	N	15	N	N	N
11.	Bottled water C (Refrigerator)	N	N	10	N	N	N
12.	Bottled water C (Sun)	N	N	8	N	N	N

2.5. Microbial Contamination in Bottled Water after Three Months of Storing

Table (8) indicates that 4 samples (33%) contain TBC (> 100 cfu/ml); and 2 samples (16.6 %) contaminant with total coliforms (3-10cfu/100ml) and molds (10-15cfu/100ml).

Table (8): Microbial Contamination in Bottled Water after Three Months of Storing

No.	Source of sample	TC	FC	TBC	Ps.a.	Molds	Yeasts
1.	Bottled water A (Dark)	N	N	80	N	N	N
2.	Bottled water A (Sun)	N	N	N	N	N	N
3.	Bottled water A (Fresh)	3	N	>100	N	10	N
4.	Bottled water A (Room Temp.)	N	N	50	N	N	N
5.	Bottled water B (Refrigerator)	N	N	20	N	N	N
6.	Bottled water B (Sun)	N	N	>100	N	10	N

7.	Bottled water B (Fresh)	10	N	>100	40	15	N
8.	Bottled water C (Dark)	N	N	>100	N	N	N
9.	Bottled water B (Room Temp.)	N	N	5	N	N	N
10.	Bottled water C (Refrigerator)	N	N	2	N	N	N
11.	Bottled water C (Sun)	N	N	N	N	N	N
12.	Bottled water C (Room Temp.)	N	N	N	N	N	N

3. Limitations

Most critical issues that rose up during sample collection were that some of desalination plants administrators refused to give out water sample, some desalination plants do not posses water vehicle tankers, some water distribution vehicles do not follow a particular desalination plants and do not have plate's number. The amount of the marketed bottled water during data collection period has been limited.

Discussion

1. Total coliforms

The results indicate that marketed drinking water in Gaza city is highly contaminated with various types of bacteria. The desalination plants, water vehicle tankers, and water distribution points are contaminated with total coliforms bacteria that exceeds WHO standards for these types of bacteria. 12 desalination plant (60%) out of 20 have been contaminated with total coliforms (1-50 cfu/100ml); 6 water vehicle tankers (50%) out of 12 have been contaminated with 1-20 cfu/100ml; and 15 distribution points (60%) out of 25 distribution points have been contaminated with total coliforms (1-50 cfu/100ml).

These results indicate that marketed drinking water in Gaza city have been highly contaminated and it requires an immediate intervention when it comes with treating and managing these serious problems. Our results on the source of fresh water treated in the Reverse Osmosis plants, it seems that private wells are less saline than the municipal wells. Furthermore, many of the water providers hygienically treat water resources that accumulated these types of bacteria.

It is a critical issue that the distributor's non-compliance with WHO water standard. However some of water distribution systems for any desalination plant, water vehicle tankers, or water distribution points are not licensed by the government.

Our results seem to be consistent with the study by Cassin et al., (2006). They found out that the level of contamination with total and fecal coliforms exceeded that of WHO limit for water wells and networks. Furthermore, the contamination percentages in networks are higher than that in wells.

Al-Khatib and Orabi (2004) studied "Drinking Water Contamination in Rain-fed Cisterns in three Villages in Ramallah". They found out that 87% of tested samples of drinking water are highly contaminated and in need of coagulation, filtration and disinfection based on the WHO guidelines for drinking-water. They found that 10.5% are contaminated to a lesser extent, thus, it is in need of treatment by disinfection only. Only 2.5% of the tested samples are uncontaminated and therefore, potable. They also found out that the main cause of drinking water contamination was the presence of cesspits, wastewater and solid waste dumping sites near the cisterns.

Elsewhere, Alves, et al. (2002) found out that one sample collected from reservoir supply has been contaminated by a bacterium of the total coliform group. Another study by Senta, et al. (2007) found out that total coliforms are detected in 24 samples and values are from 2 to >240/100 ml, whereas 16 samples have values above maximal allowed concentration.

In a third study, Lévesque, et al**. (**2008) found that approximately 90% of the samples analyzed are contaminated with total coliforms, with concentrations exceeding 10 CFU/100 ml. Then, Yamaguchi, et al. (2007) found out that 12 (20.0%) bottled mineral water out of 60 samples are positive for total coliform, compared with only 3 (5.0%) out of 60 samples from tap water.

2. Fecal coliforms

Fecal coliform is a sub-group of total coliform consequently found in water containing system and sometimes mentioned by other names (thermotolerant coliforms and / or *E .coli*). This type of coliforms has been found in some of drinking water available in the market in Gaza city; According to the WHO standards, coliform must be absent when water samples were investigated using the membrane filtration technique.

These results indicate that Gaza needs urgent attention since the results do not meet WHO standards for fecal coliform bacteria in drinking water. The marketed drinking water does not comply with the standards of cleaning, washing and disinfecting techniques that must be followed for potable drinking water.

Fortunately, we found out the results of our study consistent with the results of Yassin, et al. (2006). They found out that the contamination level of fecal coliforms exceeded that of the WHO limit of water wells and networks.

In addition, Kassenga (2007) found out that fecal coliform bacteria are available in 3.6% of samples analyzed with a tendency for higher contamination rates in drinking water that transferred in plastic tanks. In addition, Lévesque, et al. (2008) found out that approximately 66% of samples showed contamination with *E. coli*.

Then, Senta, et al. (2007) found out that fecal coliforms are detected in 17 samples out of 34 samples taken from private wells and values are from 2 to >240/100 ml.

But our results showed inconsistency with the study by Alves (2002). He found out that one sample of mineral water and one sample of 18 samples have been collected from the reservoir supply, contaminated by a bacterium of the total coliform group, (one bacterium/100 ml of water). None of the water samples proved contaminated by fecal coliforms when using Colilert Technique in aluminum foil.

3. Pseudomonas aeruginosa:

Pseudomonas aeruginosa has been found in various marketed drinking water in Gaza city; this includes desalination plant; water vehicle tankers, and distribution points in various levels and by well-known samples from sources of water as it needs great attention and good management. 9 desalination plants (45%) out of 20 have been contaminated with *P. aeruginosa* (1- 200 cfu/250ml); 6 water vehicle tankers (50%) out of 12 water vehicle tankers have been contaminated with *P. aeruginosa* (1-20 cfu/250ml); and 12 distribution points

(48%) out of 25 distribution points have been contaminated with *P. aeruginosa* (1-65 cfu/250ml).

The availability of *P. aeruginosa* in drinking water is an indicator of water quality deterioration; it's also considered as another indicator of another types of bacterial contaminant. The availability of bacteria and other types in the drinking water related to non-compliance with appropriate cleaning systems, and non–hygienic procedures that the distributors follow.

In a study by Schillinger and Knorr (2004) entitled "Drinking Water Quality", they found out statistically significant associations between operator accessibility and availability of fungi, *Pseudomonas* spp., and *Pseudomonas aeruginosa*, and between availability of fungi and the servicing interval.

In another study by Baumgartner, et al. (2006) entitled "Bacteriological Quality of Drinking Water from Dispensers (Coolers) and Possible Control Measures", the authors found out that 35 (21.6%) of 162 water samples (10 ml) from coolers yielded *P. aeruginosa*. It also suggests potential growth of *P. aeruginosa* in the dispensers. Pulsed-field gel electrophoresis typing and antibiotic susceptibility testing, found 19 *P. aeruginosa* isolates from the coolers and bottles to be identical to each other. It indicates that a single strain of *P. aeruginosa* has been originated from the bottled water rather than the surroundings of the coolers.

4. Fungi (Molds and Yeasts):

Another aspect has been measured in water samples is Fungi. It includes (Molds and Yeasts). It has been found by alarming numbers in water sample including the three main collected points of marketed drinking water desalination plant; water vehicle tankers; and water distribution points. 5 desalination plants (25%) out of 20 have been contaminated with molds (1-10 cfu/100 ml); 10 water vehicle tankers (83.3%) out of 12 cars contaminated with Molds (1-15cfu/100ml); and 14 vends (56%) out of 25 distribution points have been found contaminated with molds (1-20 cfu/100ml).

4 desalination plant (20%) out of 20 have been contaminated with yeasts (1-50 cfu/100 ml); 6 water vehicle tankers (50%) out of 12 have been contaminated with yeasts (1-20 cfu/100ml); and 4 distribution

points (14%) out of 25 distribution points have been contaminated with yeasts (1-20 cfu/100ml).

Molds and yeasts take long period to grow. Its occurrence depends on the period of water storing. This situation can be supported by more period of water storing, the susceptibility of fungi growth increases. Our results indicates that there are molds and yeasts in the collected samples. This availability of molds and yeasts is due to a long period of storing and non-compliance with frequent or regular cleaning.

Hinzelin and Block (1985), found out that in 38 samples, (50%) contain yeasts and (81%) contain filamentous fungi. Concentrations ranged between 1 and 28 yeasts per liter, and between 2 and 65 filamentous fungi per liter.

Nagy and Olson (1982) found out that the mean number of filamentous fungal colony-forming units per 100 ml of drinking water is 18 in the unchlorinated, and it is 34 in the chlorinated systems. The majority of filamentous fungi isolated are saprophytic deuteromycotina. The four most frequently occurring genera are *Penicillium*, *Sporocybe*, *Acremonium*, and *Paecilomyces*. In the chlorinated system, only physicochemical parameters are correlated with observed fungal frequencies, whereas in the unchlorinated system, none of the parameters exhibited has shown significant correlations with fungal numbers.

Then, Yamaguchi, et al. (2007) found out that yeasts are available in (36.6%) of the bottled mineral on water dispensers and (11.6%) of tap water samples from municipal system.

Furthermore, Hageskal and co-workers (2006) found out that the mycobiota of water should be considered when the microbiological safety and quality of drinking water are assessed. They recommended that molds in drinking water should possibly be included in the water supply and drinking water regulations.

Recommendations:

Water sources, water vehicle tankers and water distribution points must be licensed and periodical analyses and checks should be performed to guarantee the application of WHO standards and regulations for safe drinking water and the distribution systems must be monitored by the Palestinian Water Authority. Municipality wells (current or under construction) should be used as sources of water for the desalination plants instead of private or irrigation wells to grantee the safety of drinking water.

Municipality must follow up with all water sources in its area of jurisdiction and responsibility, meanwhile Water Authority must designate specified water source for all distributors to grantee water quality and safety and should make direct connection with the municipalities to be updated with and informed by the standards of drinking water and its safety to the consumers, however comprehensive planning should be made for continuous monitoring of water resources, especially the contaminated ones. Further study is needed to determine the factors responsible for the presence of coliforms in drinking water.

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