# Evaluation of Common and Small Scale Brackish Water Desalination Plant for Drinking Purposes in Gaza Strip at 2009

Prof. Dr. Yousef Abu Mayla / Director of Institute of Water and Environment
Eng: Salem Abu Amr / Ministry of Heath - Gaza
Eng: Omar Shatat / CMWU – Gaza

## 1. Introduction:

Gaza Strip lies on the southwestern part of the Palestinian coastal plain. Its total area is 365 $km^2$ and its length is approximately 45 km forming a long narrow rectangle (PHG, 2001). Palestine as all south Mediterranean country that suffering from decreasing quantity of available fresh water to use, in addition to falling of water quality. This problem is more severely in Gaza Strip as available water quality to use, especially for drinking purposes. (PWA, 2003). About 63.5% of water wells sampled are chemically polluted and 15.8% are bacteriological contaminated (MOH, 2004). Desalination provides a mean of upgrading saline water (poor quality) to produce fresh water. This method has been practiced regularly for over 50 years and is a well-established means of water in many countries throughout the world (Semiat, 1999).

Due to the high salinity of water wells close to the Mediterranean coastal line of Gaza strip territory and having regards to the essential and crucial needs to over come both the water scarcity and salinity, one of the medium term solutions has been initiated to spot point the eastern water wells far away to the east from coastal line (CMWU, 2009). The latest reports issued by PWA water resources department shows the trend of rapid quality deterioration for several water wells of western Gaza aquifer particularly with respect to chloride and TDS concentrations which are dramatically jumped over during the past few years (CMWU, 2009).

The demand on water in Gaza Strip is growing rapidly due the population growth. The high salinity of the water and other contaminants, in addition its bad health effect, undesirable tastes a motive to find new resource from the desalination and quality improvement infrastructure. Moreover, the strategic long term solution for water scarcity and salinity in Gaza strip was planned as per integrated aquifer management plant to divert all efforts towards the construction of regional sea water desalination plant on the Mediterranean sea (CMWU, 2009). The desalinated water in Gaza Strip has been developed by the time .so there was increasing in the small desalination plants constructions. Moreover, no enough information for quantity produced and quality. The plant location and the ability to pay were not analyzed and selected properly. The operation and management of these plants are not controlled.

**Study Objectives**

The study work is intended to achieve the following objectives:

1. To evaluate the desalinated water quality of the common and privet small scale plants in Gaza Strip.
2. To describe and assess the management and operation of the small scale desalination plants
3. To provide real knowledge about recent developments in the small scale desalination plants in Gaza governorates for the public**.**

4. To evaluate customer opinion for desalinated water quality, produced and consumed in addition to the customer ability to pay
5. To assess knowledge of consumers about the quality of water they have to drink

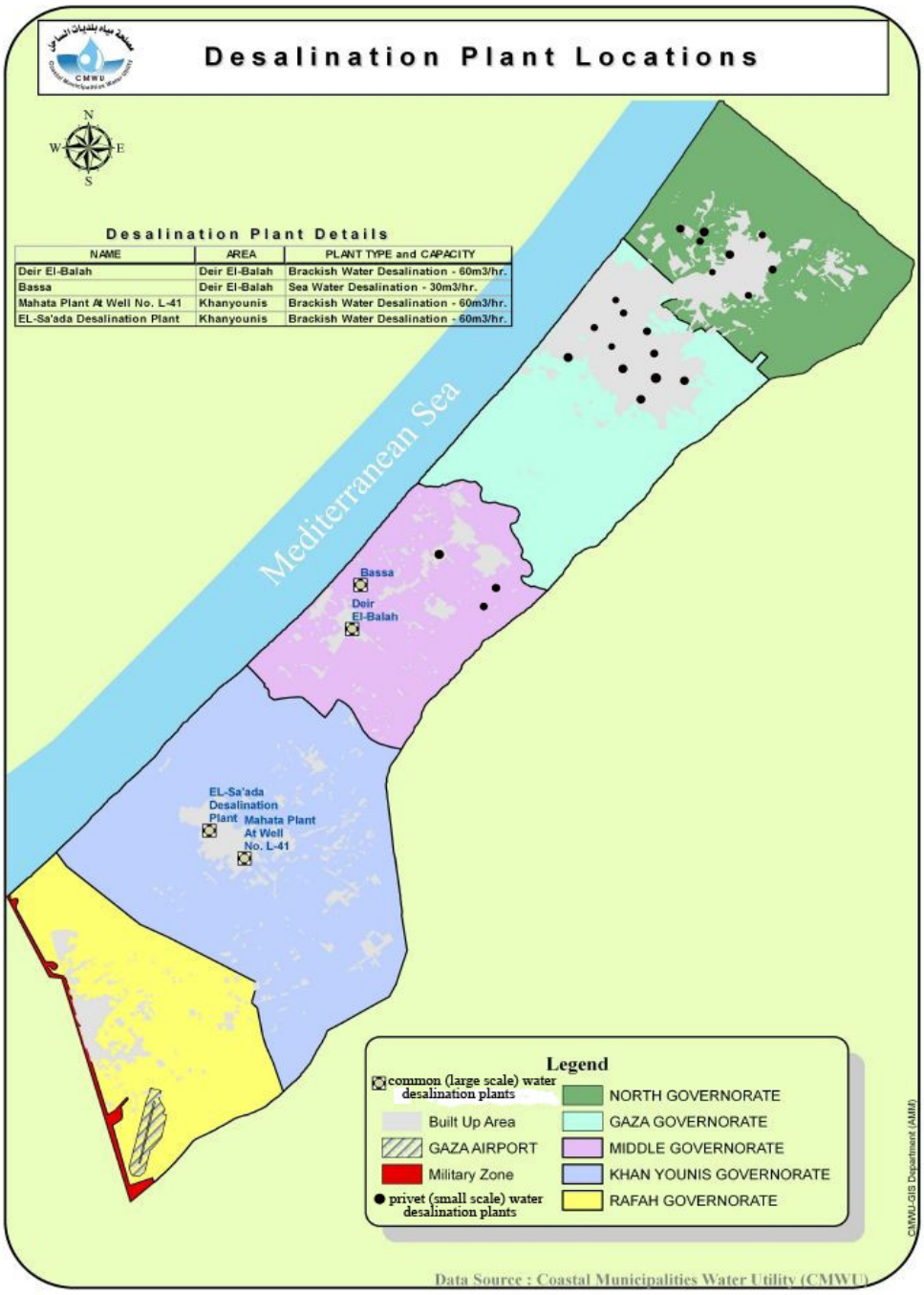


**Fig. (1).**Geographical locations of large and small scale water desalination plants in Gaza Strip.

## 2. Methodology

### 2.1. Literature Review

- Water quality in Gaza Strip
- Large scale water desalination plants (Reverse Osmosis)
- Small Scale water desalination plants (Reverse Osmosis)
- WHO and Palestinian Guidelines for the drinking water quality

### 2.2 Questionnaires and sites visits

- A total of 27 questionnaires, (depend on desalinated plant number), were planned and distributed for privet small scale desalination plants to evaluate the operation and managements of these plants.
- A total of 350 questionnaires were planned to be randomly distributed to persons who consume desalinated water from privet small scale plants. Around all Gaza strip.

### 2.3. Water samples and laboratory tests

- A total of 87 samples were collected for chemical examination and 92 samples for microbiological examination from all small Scale water desalination plants (inlet and outlet), Tanker cars and fixed tanks in Gaza Strip during the period from 8-2008 to 4-2009.
- Chemical and microbiological examination have been don at laboratory of PHG and public health laboratory at MOH,

### 2.4. Data processing and analysis

- Data analysis was conducted within the framework of the study objectives.
- Data was analyzed (Questionnaire analysis, chemical and microbiological analysis results of samples) by using Microsoft Excel and Statistical Program for Social Sciences (SPSS).

### 2.5 Chemical and microbiological analysis results of samples (by Excel program)

- A comparison between WHO guidelines and Palestinian guidelines for drinking water and the average concentration of the respective water elements in the groundwater in order to evaluate the needs of desalination in Gaza strip, and to identify the elements that need to be removed.
- Evaluation the plants location according to groundwater quality by analyzes the inlet water quality (raw) for each plant.
- A comparison was done between the inlet and outlet the tested water samples results in order to evaluate the efficiency of these plants in elements removals, also another comparison between the concentration of elements in desalinated water and the optimal water elements was done to study the suitability of desalinated water quality for drinking purposes.

## 3. Location and Spatial distribution of the desalination plants:-

Table (1), shows the summary of the RO water treatment plants in Gaza Strip which is managed by Coastal Municipalities Water Utility (CMWU).

It is clearly identified that the total number of the pants is six wells, one in Gaza, one in El Burige camp, two in Khan Younis, two in Deir El-Balah.

While the other 29 wells which are not belong to the Municipalities or (CMWU) distrusted as identified in table (2).

## 4. Schematic Brackish RO Plant Process Diagram

Figure 2. Show the schematic brackish RO plant process diagram in Gaza Strip. Raw water of total max TDS ranging from 3000 to 4000 ppm and chloride concentration range up to 1700 ppm shall be drawn from existing brackish water well through multimedia filter down to 4" diameter stainless steel mesh screen and 5 micron cylindrical cartridge filters. Chemical pre-treatment of raw water to control the raw water PH shall be applied by fully controlled hydraulic acid 33% dosing system linked with PH monitoring meter.

Consequently, the water shall be pumped through the skid RO membranes to generate the permeate water, where the brine water shall be rejected to the purposely and environmentally prepared drainage system which will be finally drained to the sea via the existing channel and drainage piping. The permeate water produced from the RO membranes shall be collected in small 20m3 water tank with booster pump , where blending quantity of well water shall be added and controlled to achieve final product of total TDS not greater than 300ppm.Post treatment to control PH and chlorine water disinfection shall be maintained before pumping the water to the distribution network by the booster pump. The quantity of produced permeate water from RO membrane shall be $50m^3$/hour to be pumped to the existing reservoirs at the station for blending then distributed through the water network (Amjad et. al, 1998).

Also, the unit shall be fully equipped with anticipant chemical treatment and controlled backwashing process including residual chlorine monitoring program for both inflow and out flow water of the designated plant.

Schematic Brackish RO Plant Process Diagram

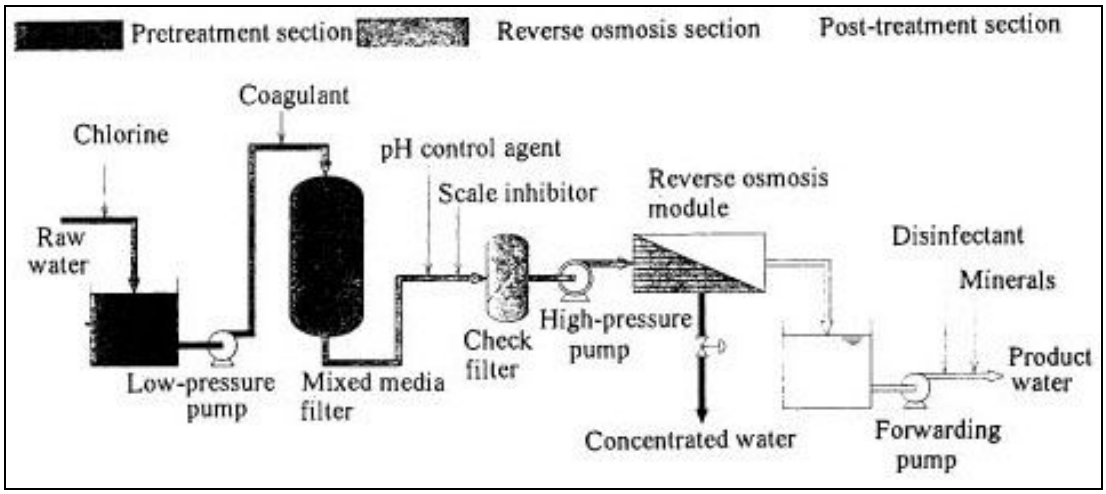


**Fig.(2).** Fully automated Skid Mounted Packaged RO Brackish Water Desalination Plant

**Table1.** List of RO Water Treatment Plants in Gaza strip managed by CMWU:

| No. | Plant Designation Name | Location | Water source | Funded by | Year of installation | Raw water | | Product Water | | Recovery rate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Year | Quantity $m^3/hr$ | **TDS ppm** | Quantity $m^3/hr$ | **TDS ppm** | % |
| 1. | Deir Al Balah brackish water RO desalination plant | Deir AL Balah | Water well J32 | Israel Occupation Civil Administration | 1992 | 80 | **3900** | 60 | **200** | 75 |
| 2. | Al Mahta Al Sharqiya Brackish water RO Plant | Khan-Younis | Water well L41 | Italy | 1996 | 80 | **2900** | 60 | **200** | 75 |
| 3. | SAADA Brackish water RO Plant | Khan-Younis | Water well L87 | Italy /CISS | 1996 | 80 | **3100** | 60 | **200** | 75 |
| 4. | Deir Al Balah RO Sea water desalination plant | Deir Al Balah | Sea water – beach wells | Austrian | 2003 | 75 | **38000** | 30 | **400** | 40 |
| 5. | Al Bureij Sea water desalination plant | Al Bureij | Water well – S72 | Italy –GVC – ECHO | 2009 | 65 | **2500** | 50 | **200** | 75 |
| 6. | Industrial state brackish water RO Plant –East Gaza *** | Gaza | Water well | USAID | 1998 | 30 | **3400** | 40 | **150** | 75 |
| **Total** | | | | | | | | **300** | | |

***: As a result of security conditions close to the eastern Gaza borders and the closure of Industrial zone ,the plant was closed three years ago .

## Note:

All plants provided here above were originally designed and constructed to produce treated water and pump it through distribution network after some blending .The chloride (CL)and nitrate (NO3) concentration for permeate water have been controlled not to exceed WHO figures and guidelines of not exceeding 250ppm for chloride and 50ppm for nitrate.

# 5. Results and discussion:

## 5.1. Small Scale water desalination plants in Gaza strip

As a result of bad quality of drinking water in Gaza Strip, the investments in small desalination plants construction had been developed in Gaza Strip since 1997, Between 1997 and 2004 the total numbers of these plant is 29 plants in Gaza Strip, table, these plants considered as apart of water salinity solution but the random constructions of these plants affect on purchase the aim of desalination the brackish water and produce the good quality water. Due to the bad security situation in Gaza Strip , road closes between Gaza Strip , only 22 plants(8 plants from North, 11 plants from Gaza, and3 plants from Middle governorates) had been covered by this study, also there was new plants constructed after finishing of sample collecting period.

### 5.1.1. Water Quality in Gaza Strip and the distribution of the plants

The results of comparison between the water quality in Gaza strip and both of WHO standards and Palestinian Standards indicate that, the water quality in North area is under both

standards in most elements concentration as average except the nitrate concentration, so in this area the need is to nitrate removal only.

In Gaza governorate there are high concentration of Sodium and Fluoride only while both the salinity and Nitrate concentrations are high in Mid Zone. Most of the elements are higher than both of the standards in Khan Younis, but in Rafah, nitrate and sodium concentration are high.

**Table (2): Water Quality in Gaza Strip and the distribution of the plants**

| Governorates | Population | Total no. of Desal. Plants(29) | | Chemical water quality in Gaza Strip (average concentration) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No | % | TDS | Cl | NO3 | Na | Ca | Mg | Hard. | F- |
| North | 300,412 | 8 | 27.6 | 813 | 141 | 88 | 87 | 62 | 46 | 347 | 1.3 |
| Gaza | 550,871 | 13 | 44.8 | 1404 | 497 | 138 | 310 | 98 | 64 | 512 | 3.12 |
| Mid Zone | 200,681 | 4 | 13.8 | 1877 | 673 | 99 | 460 | 93 | 72 | 532 | 1.5 |
| Khan younis | 300,122 | - | - | 1728 | 608 | 172 | 460 | 72 | 63 | 437 | 2.3 |
| Rafah | 200,647 | 4 | 3.18 | 962 | 243 | 100 | 210 | 49 | 43 | 239 | Not available |
| WHO Standard | | | | 1000 | 250 | 45 | 200 | 100 | 60 | 500 | 1.5 |
| Palestinian Standards | | | | 1000 - 1500 | 600 | 70 | 200 | 100 - 200 | 100 | 600 | 1.5 |

Source: of the water quality is MOH periodical analysis results for autumn season –2007, Palestinian Central Bureau of Statistics. 2006

This comparison reveal that, not only some water parameter which need decreasing in the Gaza strip (not all of them), but also the establishing of the Desalination plants was randomly without any management. As example, in the North area (with population of 300,412) which did not have any problem with salinity ,there are 8 plants (27.6% of the total plants in Gaza Strip ).while in Kahnyounis (with population of 300,122) even if most of the elements are higher than the standards, there was not any of the plants, table( 2).

### 5.1.2 Inlet water quality of studied small scale desalination plants in Gaza Strip Governorates:

**(A): North area Governorate:-**

The chemical analysis of the inlet water of the plants in North area, table (3) indicate that only one (Mashroo amer plant) from 8 plants which use water with high salinity as inlet water, that, depend on TDS and Chloride results , in the rest of the plants (7 plants) ,the inlet water have concentration less than Palestinian standards ,so chosen sources were not need desalination, in

the other hand all sources have high Nitrate Concentration so all the sources are need Denitrifiction.

**Table (3) inlet water quality of studied small scale desalination plants in North Governorate**

| No. | plant name | TDS | pH | Hard | Mg | Ca | Na | CL | NO3 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Ghadeer | 805 | 6.53 | 491 | 16.6 | 169.4 | 75.2 | 258.6 | 49.4 |
| **2** | Khayria-tuam | 2055 | 6.98 | 1086.2 | 172.6 | 150.6 | 453.2 | 1148.9 | 65.5 |
| **3** | Methali | 650 | 6.92 | 562 | 72.4 | 10.78 | 97.3 | 174.4 | 94 |
| **4** | Rasheed | 465 | 6.77 | 417.6 | 23.7 | 128.2 | 50.3 | 106.8 | 160.8 |
| **5** | Nile | 925 | 7.03 | 631.7 | 83.9 | 114.7 | 152.5 | 286.3 | 211.2 |
| **6** | Karama | 455 | 6.81 | 358.8 | 54.3 | 54.22 | 38.5 | 95.6 | 48.5 |
| **7** | Redwan | 1410 | 7.05 | 748 | 83.6 | 161.9 | 311.2 | 496 | 227.4 |
| **8** | Yafa | 795 | 6.96 | 405.88 | 20.77 | 128.4 | 132 | 252 | 73 |
| | No. of More than Pal.St. | 1 | 0 | 3 | 1 | 0 | 2 | 1 | 8 |

**(B): Gaza Governorate:-**

The concentration of TDS and Chloride of inlet water resources of 91% of the plants in Gaza Governorate were less than Palestinian's standard, table (4), 63.6 % of the resources have high concentration in both Sodium and Nitrate concentrations.

**Table (4) inlet water quality of studied small scale desalination plants in Gaza**

| No. | plant name | TDS | pH | Hard | Mg | Ca | Na | CL | NO3 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Aqua | 1140 | 7.19 | 513.7 | 63 | 102 | 305.2 | 344.3 | 179.6 |
| **2** | Qemma | 815 | 7.07 | 304.3 | 31.8 | 69.5 | 239.8 | 284.4 | 57.17 |
| **3** | Salsabeel | 1070 | 7 | 449 | 30.7 | 128.7 | 266.4 | 374.4 | 174.7 |
| **4** | Sahaba | 1000 | 7.37 | 437.6 | 49.5 | 93.8 | 268 | 335.3 | 65.5 |
| **5** | Sehha [1] | 675 | 7.06 | 450.2 | 37.2 | 119.1 | 162.6 | 178.13 | 146.5 |
| **6** | Esraa | 335 | 7.01 | 280.4 | 26.3 | 69 | 63 | 77.5 | 28.7 |
| **7** | Sabra | 1195 | 6.99 | 604.7 | 38 | 179.6 | 263.8 | 411.3 | 218.6 |
| **8** | Khayria-zeitoun | 675 | 7 | 521.1 | 98.4 | 98.4 | 93.3 | 172.5 | 34.1 |
| **9** | Kawthar | 775 | 7.72 | 532.5 | 65.1 | 106.1 | 130.93 | 254.5 | 134.5 |
| **10** | Ein | 1135 | 6.86 | 379.6 | 36.1 | 92.6 | 290 | 307.4 | 184 |
| **11** | Fardous | 1450 | 7.11 | 598 | 81.56 | 105.15 | 483.4 | 641.25 | 43.5 |
| | More than Pal.St. | 0 | 0 | 1 | 0 | 0 | 7 | 1 | 7 |

**(C): Middle Zone:-**

The results of water quality analysis indicate that 67 %of the plants water resources in middle governorate need desalination because the salinity of the water have high concentration .but 33%of plants water resources was not need because the water have low concentrations of the elements .so this plant (Alkhayrya abu medden) work on very good drinking water resources, table (5)

**Table (5) inlet water quality of studied small scale desalination plants in middle Governorate**

| No. | name | TDS | pH | Hard | Mg | Ca | Na | CL | NO3 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Forat | 2065 | 7.38 | 714.8 | 96.2 | 127.7 | 639.3 | 1003 | 33.7 |
| **2** | Shallal | 2095 | 7.55 | 775.5 | 104.5 | 138.5 | 642.5 | 1016.4 | 35.1 |
| **3** | Janoub | 360 | 7.05 | 221.4 | 20.2 | 55.21 | 61.29 | 110.77 | 27.2 |
| | More than Pal.St. | 2 | 0 | 2 | 1 | 0 | 2 | 2 | 0 |

### 5.1.3 Evaluation of inlet and outlet water quality in small scale desalination plants in Gaza Strip

- **Chemical water quality of inlet and outlet water**

Small scale desalination plants in Gaza strip consist of different filters (sand filter, carbon filter, Antecedents, RO filter)

The main filter of the desalination plants reverse Osmosis filter . This filter is very effective ,the purification degree of it could reach to the 99% of the elements,but this degree controlled by many defferent factors like ( inlet water quality, running time of the filter, inlet water pressure ) . the most important factor is the inlet water quality that ,highlly affect on the element removal effeciency and on the desalinated water quality.

The quality of some elements in both inlet and outlet of the mall desalination plants in Gaza Strip were studied in case of evaluation both of outlet water( desalinated ) quality and plants removal effeciency

**1**. **Total dissolved Solids**

The total dissolved solid of 59.1% of the inlet water samples was under both of WHO and palestinian stndards (1000mg/l) ,also 27.3% of the samples have TDS concentration accepted by the Palestinian standard (1000-1500 mg/l) (PHG, 2002). The rest of the samples (13.6 %) have TDS concentration higher than the standards (2000-2500mg/l).The low concentration of the TDS in the inlet samples affect on the analytical results of the outlet samples ,that 100% of these samples contain TDS concentration less than 200mg/l ,90.1% of the samples have TDS concentration less than 100 mg/l ,fig (3 ) .

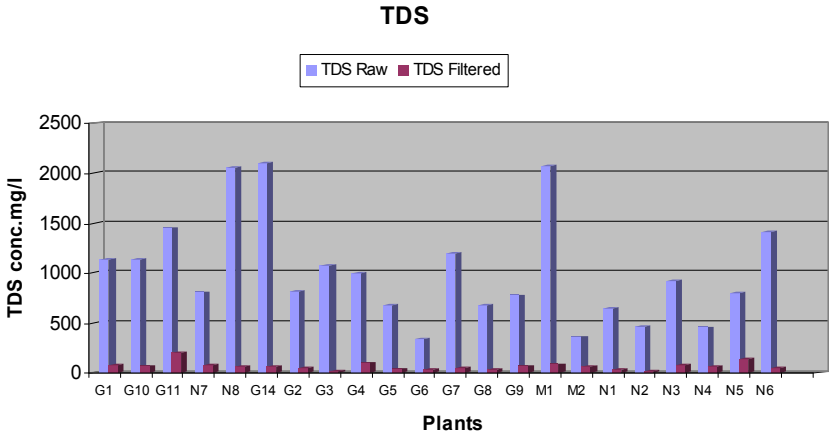


**Fig.(3)** TDS concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**2**. **pH value**

The analytical data of pH in the inlet water samples show that, 100% of the samples have pH under both the WHO and Palestinian standards (6.5-8.5). Due to the desalination process and the elements removal, the pH value of some desalinated water became under the minimum concentration that recommended by the WHO and Palestinian recommendations. So after desalination, water needs correction to the pH by adding (NaOH), but if this operation not happened the pH of the water will be very low. The data results show that 72.7% of the outlet water samples have pH lower than 6.5 the rest (27.3%) of the samples have pH between 6.5-7.1.figure 4.

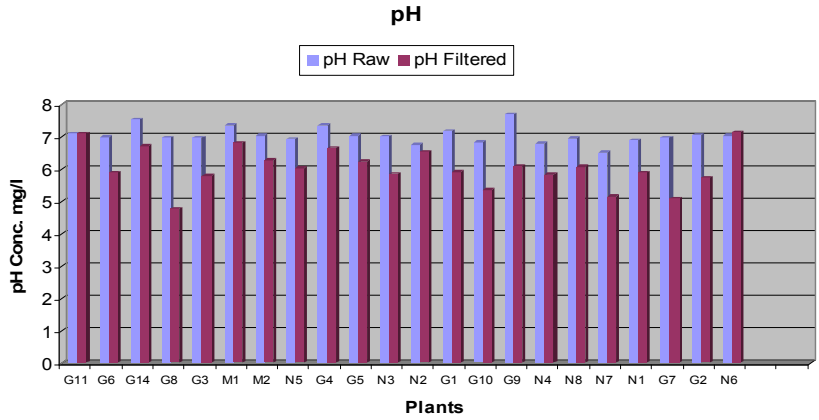


**Fig. (4)** pH value concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**3**. **Hardness concentration**

Hardness Concentration in 50% of the inlet water samples is less than the recommendations( 500mg/l) ,the rest of the samples 50% have hardness concentration higher than the recommendation

.,but the hardness concentration in the outlet samples is very low that ,95.5% of the sample contain hardness concentration (0-80mg/l)the rest 4.5% of the outlet samples contain hardness less than 120mg/l..fig (5 )

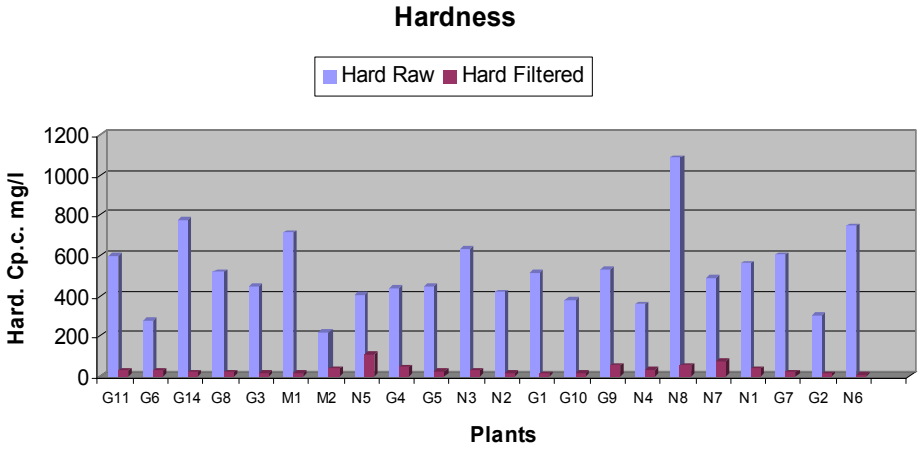


**Fig (5)** Hardness concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**4. Calcium Concentration**

The analytical data of inlet water samples show that 36.4% of the samples have calcium concentration less than the recommendations (100mg/l), 45 % of the samples have concentration accepted by Palestinian recommendations (100-150mg/l).the rest 18.6% of the samples need calcium decreasing. The Calcium concentration in the100% of outlet samples is less than 25 mg/l ,72% of these samples contain calcium concentration less than 6 mg/l. fig (6)

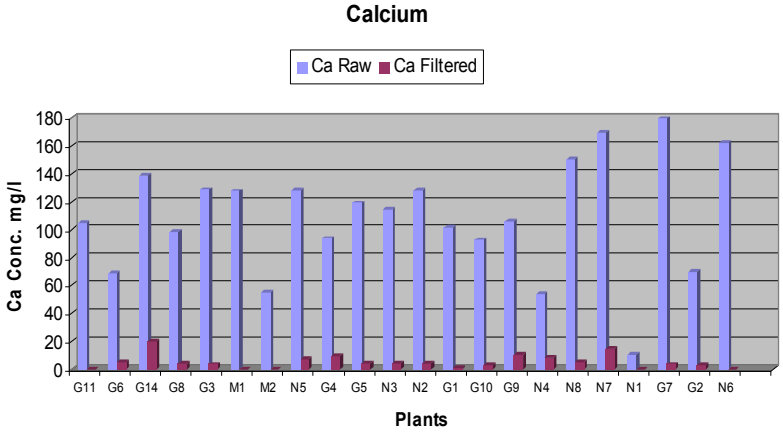


**Fig (6)**
Calcium concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**5. Magnesium Concentration**

Magnesium concentration of 91% of the inlet water samples is under the recommendation (60-100 mg/l), 9% of the sample have magnesium concentration higher than the recommendations.

But in the outlet samples, the magnesium concentration of all the samples is less than 25mg/l .95.5% of the outlet samples contains magnesium concentrations less than 10 mg/l figure 7.

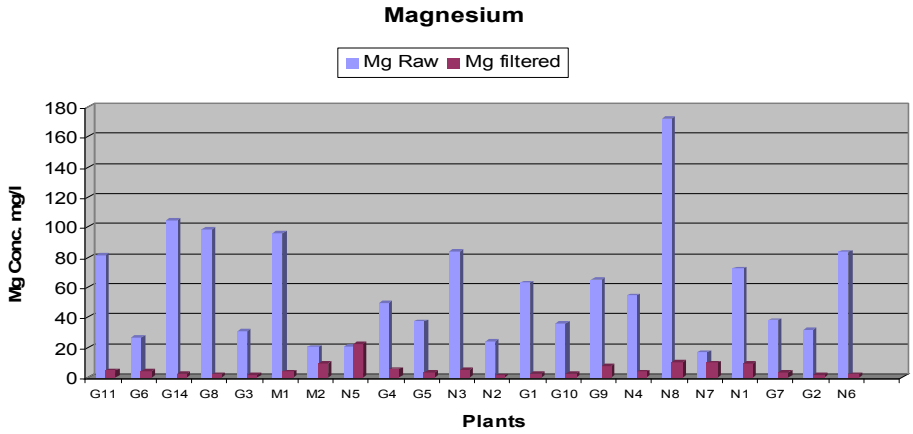


**Fig. (7)** Magnesium concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**6. Chloride concentration**

The chloride concentration in 27.3 %of the inlet water samples is less than WHO recommendation and 77.3% of the samples contain chloride concentration less than the Palestinian recommendation, while all the outlet samples have chloride concentration less than 125 mg/l. The chloride concentration in 68.2% of these samples is less than 50mg/l,27.2% of the samples contain chloride concentration less than 80mg/lthe rest of the samples 4.5% have concentration less than 125mg/l.figure 8.

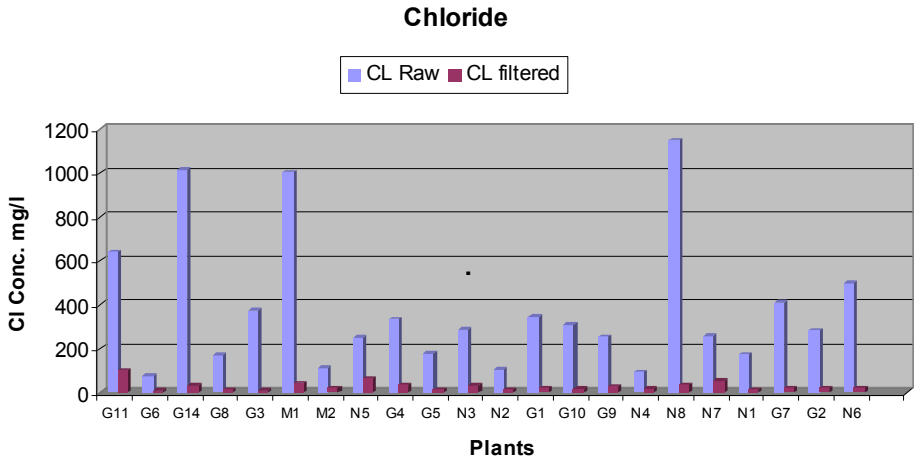


**Fig. (8)** chloride concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**7. Sodium Concentration**

The data analysis of inlet water samples show that 50% of the sample contain Sodium concentrations less than the recommendations (200 mg/l).the other 50% of the samples need

Sodium concentration decreasing. The data analysis of the outlet samples show that 100% of the samples contain Sodium concentration less than 30 mg/l, figure 9..

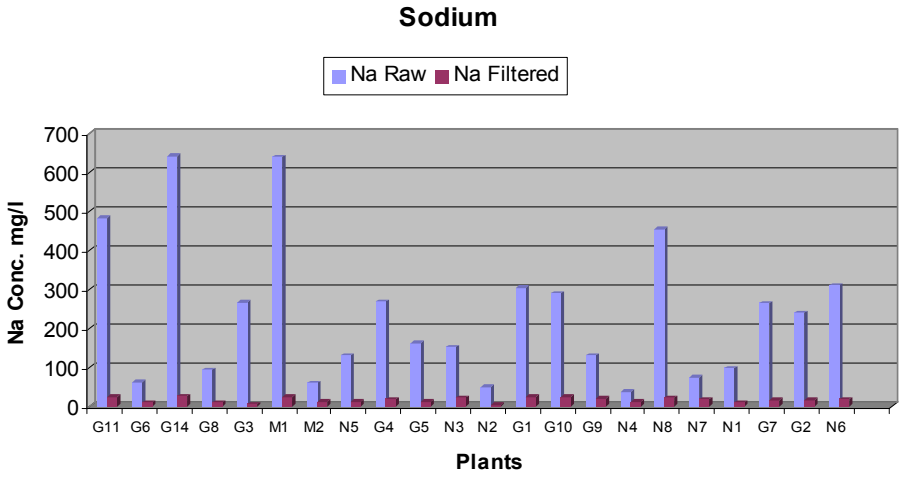


**Fig. (9)** Sodium concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**8**. **Fluoride Concentration**

Fluoride concentration in 95.5% of the inlet water samples is less than the recommendations (1.5 mg/l) the rest 4.5% of the samples need fluoride concentration decreasing, while in 90.9% of the outlet samples the fluoride concentration is less than .1 mg/l and in 4.5% of the samples is less than .5 mg /l. So around 95% of the outlet samples need fluorination. , fig (10)

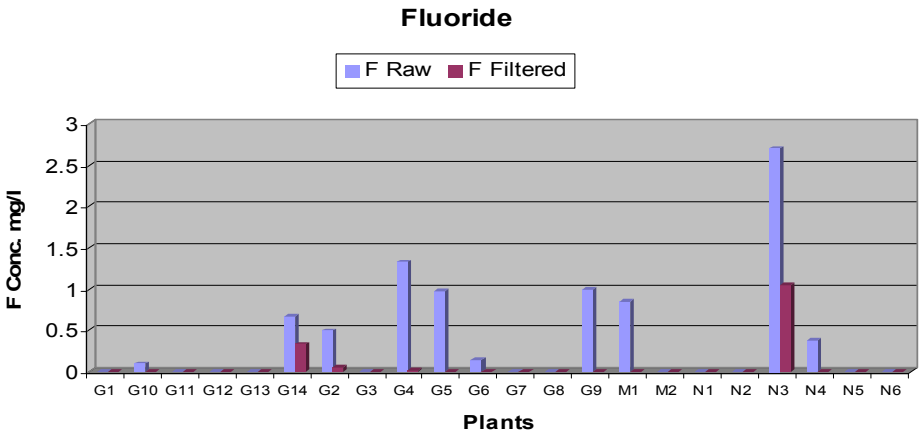


**Fig (10)** fluoride concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

**9. Nitrate concentration**

The Nitrate concentration in 27.3% of the inlet water samples is less than WHO recommendation (45mg/l) and 50%of the samples have nitrate concentration less than Palestinian recommendation (70mg/l).the rest of the samples need Denitrifiction.

All the outlet samples contain nitrate concentration less than 40mg/l,27.3% of these samples have nitrate concentration less than 10mg/l,fig (11).

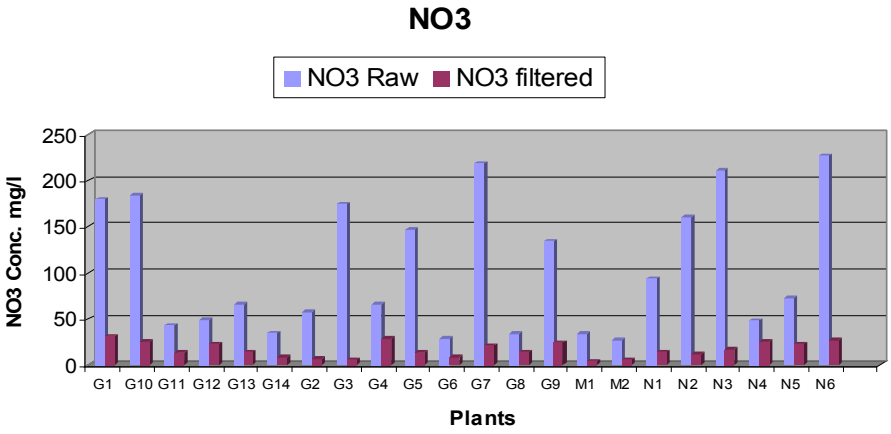


**Fig (11)** Nitrate concentration in inlet and outlet samples of small scale water desalination plants in Gaza Strip

### 5.1.4. Plants efficiency according to the elements removal:

The differences between the concentrations of the same elements in both inlet and outlet water convey the removal efficiency of the plants. Many factors control this efficiency, the main one is the inlet water quality. The data analysis of the same elements concentration in outlet and inlet water of the 22 plants show that , the removal efficiency percentage (90-100% ) of the plants for each elements was respectively (77.3% TDS removal, 54.6% Chloride removal, 63.6 % Na removal, 72.7% Hardness removal , 91% Calcium removal,63.6% magnesium removal, and 22.7 % Nitrate removal ), 54.6% of the plants have total removal efficiency percentage from 90-100% , table (6 )

**Table (6) Elements removal efficiency of the plants in Gaza strip:**

| plant name | TDS r.ef.% | CL r.ef %. | Na r.ef.% | Hard r.ef.% | Ca r.ef.% | Mg r.ef%. | NO3 r.ef.% | total effe. |
|---|---|---|---|---|---|---|---|---|
| **Alsabra** | 93.0 | 93.0 | 91.4 | 97.8 | 99.4 | 96.2 | 82.5 | 93.3 |
| **Salsabeel** | 93.9 | 92.0 | 93.0 | 95.8 | 96.1 | 95.2 | 88.5 | 93.5 |
| **Alisraa** | 98.1 | 96.7 | 97.8 | 96.6 | 97.3 | 94.7 | 96.6 | 96.8 |
| **Alkh.zayt** | 90.0 | 89.2 | 92.7 | 89.0 | 90.0 | 89.0 | 56.5 | 85.2 |
| **Alkwit** | 94.1 | 91.3 | 92.7 | 94.4 | 97.0 | 90.3 | 91.0 | 93.0 |
| **Aleen** | 89.5 | 83.6 | 83.2 | 89.1 | 92.2 | 84.1 | 69.0 | 84.4 |
| **Sahha** | 95.8 | 95.0 | 93.6 | 96.3 | 98.1 | 91.3 | 90.4 | 94.4 |
| **Algemma** | 94.8 | 91.4 | 89.0 | 96.3 | 96.0 | 97.8 | 57.8 | 89.0 |
| **ferdaws** | 91.0 | 89.1 | 84.2 | 89.5 | 90.4 | 88.6 | 81.6 | 87.8 |
| **Alsahaba** | 93.8 | 93.5 | 91.4 | 95.5 | 97.0 | 93.1 | 86.4 | 93.0 |
| **Akwa** | 86.2 | 84.3 | 95.0 | 94.8 | 100.0 | 94.4 | 68.3 | 89.0 |
| **methalee** | 90.1 | 79.0 | 74.5 | 84.4 | 91.4 | 40.4 | 53.0 | 73.3 |
| **Mash.Amer** | 96.8 | 96.9 | 95.1 | 95.0 | 96.8 | 94.0 | 78.1 | 93.2 |
| **rasheed** | 95.4 | 91.4 | 89.9 | 93.0 | 100.0 | 86.9 | 84.3 | 91.6 |
| **Alredwan** | 95.7 | 87.6 | 92.2 | 96.4 | 97.1 | 94.3 | 92.7 | 93.7 |
| **Alneel** | 91.4 | 88.6 | 84.5 | 95.0 | 96.3 | 94.0 | 92.1 | 91.7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Ghadeer** | 86.8 | 80.2 | 65.2 | 90.0 | 84.6 | 93.2 | 46.8 | 78.1 |
| **Aljanoub** | 95.9 | 95.7 | 96.2 | 97.9 | 100.0 | 96.2 | 88.1 | 95.7 |
| **Alforat** | 97.1 | 96.7 | 95.7 | 97.4 | 85.0 | -6.9 | 76.4 | 77.4 |
| **Alkh.twam** | 83.0 | 74.1 | 90.0 | 73.0 | 94.3 | 53.9 | 68.1 | 76.6 |
| **Alkh.medeen** | 83.33 | 81.4 | 79.4 | 82.7 | 100.0 | 54.0 | 77.0 | 79.7 |
| **yafa** | 96.45 | 95.9 | 93.8 | 98.8 | 100.0 | 97.4 | 88.1 | 95.8 |

### 5.1.5. Microbiological water quality:

The most important aspect of drinking water quality is microbiological quality. It's not practicable to taste the water for all organisms, which may cause disease (pathogens) WHO, 1996). The data analysis of Microbiological tests for the inlet and outlet of 22 plants (studied during the study period), show that, The total contamination percentages in inlet water is (41%for the total coliform and 27.3% for the fecal coliforms) while the total contamination percentages in outlet water is (45.5% for the total coliforms and 31.8% for the fecal coliforms ) ,table (7).

**Table (7):** total coliform and fecal coliform contamination in the water desalination plants, in Gaza Strip

| **Area** | **Name of plant** | **Total coliform** | | **Fecal coliform** | |
|---|---|---|---|---|---|
| | | **inlet** | **outlet** | **Inlet** | **outlet** |
| **Gaza** | Aqua | 3 | 0 | 0 | 0 |
| | Qemma | 0 | 7 | 0 | 0 |
| | Salsabeel | 0 | 0 | 0 | 0 |
| | Sahaba | 0 | 0 | 0 | 0 |
| | Sehha [1] | 0 | 0 | 0 | 0 |
| | Esraa | 0 | 0 | 0 | 0 |
| | Sabra | 0 | 3 | 0 | 1 |
| | Khayria-zeitoun | 0 | 0 | 0 | 0 |
| | Kawthar | 8 | 2 | 6 | 0 |
| | Ein | 0 | 0 | 0 | 0 |
| | Fardous | 15 | 13 | 6 | 2 |
| | Khayria-abo meddean | 30 | 26 | 10 | 14 |
| **North** | Ghadeer | 15 | 30 | 4 | 0 |
| | Khayria-tuam | 8 | 14 | 3 | 3 |
| | Methali | 3 | 4 | 0 | 1 |
| | Rasheed | 2 | 0 | 0 | 0 |
| | Nile | 0 | 0 | 0 | 0 |
| | Karama | 20 | 5 | 6 | 2 |
| | Redwan | 0 | 0 | 0 | 0 |
| | Yafa | 0 | 0 | 0 | 0 |
| **Mid Zon** | Forat | 0 | 3 | 0 | 3 |
| | Shallal | * | * | * | * |

| | | | | | |
|---|---|---|---|---|---|
| | Janoub | 0 | 0 | 0 | 0 |
| Total contamination % | | 41% | 45.5% | 27.3% | 31.8% |

*Were not collected samples to examine.

The term of contamination based on 1 colony forming per 100 ml examined sample (WHO, 1993).

In some plants, the contamination by total coliform and fecal coliform in inlet water is higher than that in outlet water, but in other some plants, the contamination level in outlet water is higher than that in inlet water .these results were because of the unqualified worker hose operates these plants. Generally, the contamination of water desalination plants is high which fluctuate from 2 colony to 30 colony and 1 to 14 colony by total coliform and fecal coliform, respectively. The most plants depend on ultraviolet radiation (UV) for water disinfecting which inactive against high level of contamination. Moreover, UV is unlike chlorine that leaving remainder free chlorine to protect water from external source pollution.

**5.1.6. Desalinated water quality in cars, tanks and water shops**

The data analysis of chemical tests for 13 samples from the cars and 18 samples from the tanks and water shops ),table (4 ) annex(3 ) ,confirm that , the concentration of all elements are very low because the desalinated water distribute as to the people from the plants without any elemental addition. There were some differences between the elements concentrations in desalinated water in the plants and desalinated water in the cars and tanks. This deference's may refer to the different time of samples collecting.

The microbiological tests results of the desalinated water in tanks and tanker cars were different from the same tests results for the desalinated water in the plants. The total microbiological contamination of the desalinated water in the plants was 45.5% ,31.8% total coliform and fecal coliform ,respectively , while the total contamination in tanker cars was 14.2% ,7.7% for the same tests, and for the tanks the total contamination was 25% and 13.33% ,table (8). The microbial contamination can occur as a result of the use of unsuitable materials contact with water; such materials include pipe and tank lining compounds, plastic use in pipes, tanks and faucets, all of which can deteriorate to from substances that support the growth of microorganisms.

Chlorine which added in tanker cars can be achieved some level of contamination. The time required for transport of water from plants to tanks that meet the best contact time between water and chlorine (>30 mint) led to achieving another level of contamination in the tanks. High concentration of chlorine adding in desalinated water make an undesirable test for consumers, and lower concentration my terminated before achieving of all microbial contamination; its Challenge point front of desalination plants operators. Generally, unsuitable transportation of water from tanker cars to tanks and missing of clinging for both led to still high level of microbial contamination in desalinated water.

**Table ( 8):** total coliforms and fecal coliforms contamination in the desalinated water in tanker cars and tanks in Gaza, North and Mid Zone Governorates

| Area | Name of plant | Total coliform | | Fecal coliform | |
|---|---|---|---|---|---|
| | | Tanker cars | tanks | Tanker cars | tanks |
| Gaza | Aqua [1] | * | 0 | * | 0 |
| | Qemma [3] | 0 | * | 0 | * |
| | Salsabeel | 0 | 0 | 0 | * |
| | Sahaba | 5 | 1 | 2 | 0 |
| | Sehha [1] | * | 0 | * | 0 |
| | Esraa | 0 | 0 | 0 | 0 |
| | Sabra [2] | * | * | * | * |
| | Khayria-zeitoun [1] | * | 0 | * | 0 |
| | Kawthar [1,3] | * | * | * | * |
| | Ein | 0 | 0 | 0 | 0 |
| | Fardous [1] | * | 5 | * | 5 |
| | Khayria-abo meddean | 0 | 0 | 0 | 0 |
| | Makka [1] | * | * | * | * |
| | Fayomi [1,3] | * | * | * | * |
| North | Ghadeer [1] | * | 0 | * | 0 |
| | Khayria-tuam [1] | * | * | * | * |
| | Methali | 6 | 18 | 0 | 0 |
| | Rasheed | 0 | 0 | 0 | 0 |
| | Nile [2,3] | * | * | * | * |
| | Karama [3] | 0 | * | * | * |
| | Redwan | 0 | 0 | 0 | 0 |
| | Yafa | 0 | 2 | 0 | 2 |
| Mid Zone | Forat | 0 | 0 | 0 | 0 |
| | Shallal [1] | 0 | * | 0 | * |
| | Janoub | 0 | 0 | 0 | 0 |
| **Total contamination %** | | **14.2%** | **25%** | **7.7%** | **13.33%** |

*Were not collected samples to examined
[1] unavailable to collected samples
[2] there is no tanker cars
[3] there is no tanks

## 6. Conclusions and Recommendations

### 6.1. Conclusions:-

Due to the bad quality of Municipal water in Gaza strip, desalinated water use increases and the availability of renewable supplies decreases, using of desalinated water increases by the people. Small Desalination plants become more popular way to obtain potable water for cities. Growing demand for safe, clean water, combined with drought conditions and increasing

populations, are driving the market for desalination plants. This market is expanding to offer fresh opportunities to new and established market participant. The number of competitors in the market is expected to increase as the number and size of desalination plants grows. This increase in competition will maximize plant efficiency, making the cost of desalinated water more attractive to consumers. These plants depend on the RO. filters as the main process of the desalination so the product water contains very low concentrations of water parameters. The study deals with the Small desalination plants in Gaza Strip (managements and operation) to evaluate these plants mainly water quality, and to provide real knowledge about these plants for the consumers.

Also there was concentrated on the desalinated water consumers to evaluate customer opinion for desalinated water quality, produced and consumed in addition to the customer ability to pay and to assess knowledge of consumers about the quality of water they have to drink. The results show that:-

- There was not any management of plants establishing according to location of water sources needs desalination in Gaza Strip.
- There are wide variations of water quality in Gaza Strip, that not all the water in Gaza Strip needs the same elements removal technology.
- The inlet water quality in most plants were less than WHO and Palestinian standards with high desalination efficiency led to completely removed of essential elements that important to human health
- The total contamination (microbiological tests ) percentages in inlet water is (41%for the total coliform and 27.3% for the fecal coliforms) while the total contamination percentages in outlet water is (45.5% for the total coliforms and 31.8% for the fecal coliforms ), in some plants, the contamination by total coliform and fecal coliform in inlet water is higher than that in outlet water, but in other some plants, the contamination level in outlet water is higher than that in inlet water .these results were because of the unqualified worker hose operates these plants.
- The microbiological tests results of the desalinated water in tanks and tanker cars were different from the same tests results for the desalinated water in the plants. The total microbiological contamination of the desalinated water in the plants was 45.5% ,31.8% total coliform and fecal coliform ,respectively , while the total contamination in tanker cars was 14.2% ,7.7% for the same tests, and for the tanks the total contamination was 25% and 13.33% .
- Many of plants owners need more information about the standards, also they need to be aware about the water problem in Gaza strip and how could they share in solving it, how could they mange there investment not only to gain the money but also to e part of the water problem solution in Gaza strip.

According to the consumers the small desalinated plants solve part of their drinking water quality problem.

### 6.2 Recommendations:-

1- Monitoring program for the desalinated plants include (chemical and microbiological analysis) should be developed for evaluation of the product and distributed water.
2- Adopt strategy to control the location of the small scale desalination plants construction according to the ground water quality to manage with salinity problems in Gaza Strip.

3- More studies still needs to define the water quality problem for each area alone and the solution method and technology for these problems.
4- Awareness campaign targeting the plants owners to increase there awareness about the water problem in Gaza strip and how could they share in solving it, how could they mange there investment not only to gain the money but also to be part of the water problem solution in Gaza Strip.
5- Awareness campaign targeting the consumers to increase there awareness about the drinking water recommendations and healthy water quality, also changing the Idea of them about the nature of municipal services.
6- More studies about the relation between the desalinated water consuming regularly and health changes, highly recommended.
7- Studies about the best technologies of the desalination that suitable for the water quality in Gaza strip should be conducted.
8- Raising the qualification of plants workers to prevent desalinated water quality deterioration by is highly need
9- Awareness campaign targeted to the plants owners in case of developed their information about the saline water desalination (management and operation) highly recommended.

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