

Mini Projects Solution for Energy, Wastewater and Water for the Gaza Strip, Palestine

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Abstract – Gaza has several water problems; limited fresh water supply, inefficient water use by the agricultural sector, high water demand, groundwater contamination, seawater intrusion and shortage of electricity. Water and electricity is the first priority for Gaza that will add significant positive values to the Palestinians living in blocked Gaza and easy operation and maintenance of their ongoing and exciting projects. Planning for mini projects such as desalination, wastewater collection and treatment and energy production in the Gaza Strip is urgently needed. The three projects are related to each other which can be a complete circle that is considered as basic life for any society. These projects will be distributed equally all over the Gaza Strip to be able to serve maximum number of poor people including 10 vacancies each project and 300 in total that is going to the same area. Also, the target of this study is touching directly to the most needed people (poorer first) in order to higher their life's standard and save their children from the available diseases. To start with the mostly needed area and then step wise to complete the planned projects with respect to tariffs collection from whom able to pay and then plan for the next groups of mini projects. In order to start any project and call for international funding and help, all parties in Palestine must reach a compromise.

Keywords – Mimi Projects, Desalination, Energy, Wastewater, Employment, Land Use, Basic Life, Palestine-Gaza.

I. INTRODUCTION

Gaza Strip is the most densely and populated area in the world that counted as part of Palestinian territories which almost missing everything related to living standards water sectors (inefficient water use by the agricultural, limited fresh water supply and high water demand, groundwater contamination and seawater intrusion) and electricity.

There are so many reasons for the current problems in this area in which some of them can be solved by the help of neighbouring countries and international community. In Gaza, the yearly depletion amount is about 15% of the available water in the aquifers due to miss use and not able to control the discharge of this water [1]. Digging and discharging are both done by people without any permission from the government and already some of the aquifers were previously depleted out from the settlements.

The Palestinian population in Gaza is having high growth rate with almost 4.8%, the increase of population is about 75,000 per year and according to the Central Bureau of Statistics estimates the population of the Gaza Strip will be more than 3 million by 2020. The peoples in the Gaza consume about 100 MCM/yr (million cubic meters per year), which discharged mainly from the groundwater through the municipalities [2]. Comparing the water per

capita per day for the Gaza people as they are surviving with only 20 to 70 l/day while WHO standard always telling us 100 l/day is the lowest amount can one person has just to live [3]. The problem was also found with the difficult access to the available water for Palestinians as the Israel's dose. In many recent researches it is believed that the Gaza aquifers are almost depleted and it has already passed the point with no return [4].

Gaza Strip has been blockaded since year 2007 with hardly increasing day after day due to Israeli and neighbouring country situation which is directly affecting basic life of living for the peoples. Gaza has not had sufficient fuel to sustain its electricity supply which is directly related to water and wastewater treatment facilities. Resulting, pumping stations ceased operation and many places in the Gaza Strip streets are now inundated with human excrement especially in southern Gaza City.

The United Nations recently reported that about 95 percent of the aquifer's water quality was unfit for human consumption because of pollution from seawater intrusion, fertilizers and untreated wastewater [5]. The highly important concern for the infants and the growing children is due to available chemical pollutant in the Gaza drinking water supply. It is highly recommended to apply water quality act and pollution control so that to reduce the contamination and consequently the health risk to the population [6]. In Gaza, abundance of solar radiation as source of energy can be used for seawater desalination either by producing thermal energy to drive the phase-change processes or by generating electricity to drive the membrane processes [7].

Solar-desalination systems are available in many countries but in Gaza for instance it might have difficulties to start any project due to previous and current critical situation. In 2013, Adnan has studied and investigated the contamination in drinking during the water production and delivery process in the middle area of the Gaza Strip. His finding was clearly showing the value of biological contamination of storage tanks of private desalination plants, water tankers, drinking water distribution points and drinking water household storage tanks were higher than the guidelines for drinking water compared with both World Health Organization (WHO) and Palestinian Water Authority (PWA) [8].

Also, chemical analysis of municipal groundwater wells shows that the average total dissolved solids (TDS), Cl and Na values exceed the WHO and PWA acceptable level. Feasibility studies showed that the wastewater reuse is playing as important part of water resources in water balance in the Gaza Strip [9]. Also the treated amount of wastewater can be used for irrigation to improve

agricultural sector and for aquifer recharge which can improve the economical, environmental and socioeconomically situation in Gaza.

Purposes

In general, the purpose of this study is kind of calling for help which can be divided into two parts e.g. proposals from the previous study and from latest study trying for possible implementation. Both are considered as urgent help that is needed for Gaza peoples trying to solve some of several available problems such as water sectors, water pollution and seawater intrusion. In 2011, Bashitalshaer & Persson has suggested great project for both side that letting Egypt obtaining their amount for free, more water and electricity, more employment, repairing cost and workers are cheaper, availability of chemicals [10]. Below are the list of important and prioritised purposes for this project and study:

- Building projects to increase water and electricity for both sides,
- Both side will employ more peoples for permanent employment opportunities,
- Improving the economical, politically, environmental and security for both and,
- Increasing cooperation between Egypt and Palestinians in Gaza.

Planning for mini projects such as desalination, wastewater collection and treatment and energy production in the Gaza Strip is urgently needed. This plan could solve and/or minimize the problems of water scarce, wastewater treatment and shortage of electricity. The three different projects are related to each other which can be a complete circle that is considered as basic life for any society. The purposes of these projects are as follows:

- Such projects can decrease the tension in the area,
- Supply drinking water, electricity and improve wastewater collection,
- Provide clean environment and more jobs for the peoples living in the Gaza Strip and,
- Mini projects are much safer than the mega or large scale projects.

II. STUDY AREA AND PARAMETERS

An Overview

The Gaza Strip climate is considered as a semi-arid in which Gaza has total area about 365 km² (almost 1.33% from the historical Palestine). The total length of Gaza Strip is about 40 km in which this length measured at the Mediterranean Sea coast with an average width of about 9 km and max of 15km. Gaza forms between two zones the semi-humid coastal area in the north and the semi-arid Sinai desert in Egypt and the Mediterranean Sea (see Figure 1). Gaza Strip counts five main cities Gaza main, North Gaza, Deir Al-Balah, Khanyounis and Rafah. Gaza

Strip counts 16 municipalities that serve almost 80% of the peoples living there. Gaza has about 300mm annual average rain mainly falls in winter months in which this amount is considered as the major sources of groundwater recharge. The amount of evaporation is high compared to the precipitation in which the average evaporation at open water is about 1300 mm/yr [12].

Current Situation in the Gaza Strip

The peoples in the Gaza consume about 100 MCM/yr (million cubic meters per year), which discharged mainly from the groundwater through the municipalities [2]. According to the Palestinian Water Authority (PWA), the Gaza Strip peoples consumes about 170 MCM/yr in which about 90 MCM/yr for human consumption and 80 MCM/yr used for agricultural purposes.

Although, the reported values from the world health organization (WHO), is just 13 out of 50 l/capita/day meets the standard water quality for the Gaza peoples [13].

From previous studies some harmful chemicals were found in the water analyses such as NO₃ and Cl [14]. It was also found that the nitrate is about 433 mg/l and mean of 166 mg/l, which is much higher than WHO standards (45 mg/l) and chloride about 1,290 mg/l with mean value about 491 mg/l is also very high compared to the WHO standard of 250 mg/l [3].

The result in 2012 showed that the Israeli company “Mekorot” is supplying about 57 MCM per year for all Palestinian municipalities in which just 4 MCM per year goes to Gaza Strip which counts about 30% of the municipal water supplied for Palestinians (of this just 4% goes to the Gaza Strip) [4]. The water demand is going to be doubled in 2020 to reach more than 300 MCM/y [15, 16] as the population doubled from year 2000 to year 2020 to more than 2 million inhabitant [12]. Gaza peoples are paying so much money for the water service and home units reverse osmosis (RO), so they are able to pay the water supply tariff for the new project. Also, the calculated average amount of energy prices was found between 6 to 9 cent/kWh electricity [17].

It is almost no electricity in some houses but 6 to 8 hours in good condition and the current situation of the electricity in the Gaza Strip is considered in a very bad condition. Recently, it was calculated by the Palestinian President’s Office and the Gaza Power Generating Company (GPGC), 28 MW comes from Egypt, 120 MW from Israeli company lines and 100 MW from the power generation company, these values are counted together 55% of the Gaza need and the missing amount is 45%. At the same time the collection of electricity cost from the customers in Gaza became very difficult day after day due to their unemployment, low salaries and blockade (not all population). Figure 2 is the most expressive to see what is going on in Gaza Strip and it is the most recent situations available over the whole Gaza Strip [18].



Fig. 1. Map of Gaza Strip in Palestine (after Wikipedia access 2015-08-18) [11].



Fig. 2. The current situations in the Gaza Strip, www.paltoday.ps (reported in Aug. 2015) [18].

Important to Know

Rainfall: The Gaza Strip rainfall is considered as the main source of surface and groundwater and the main source of feed water to the coastal aquifer but is not collected properly [4, 19]. The total amount rainfall volume (exceptionally) was calculated between Sep. 2011 and Aug. 2012 is about 136 MCM/yr, of this amount about 64 MCM is estimated to recharge the groundwater [4].

Surface and Groundwater: The measured total dissolved solids TDS, was found very high level in most places of the Gaza Strip and it reaches more than 2000mg/l and chlorine is between 1000-3000mg/l [19]. In Gaza, everything depending and running by electricity such as RO house unit, small desalination plant and water supply from the municipalities, so more electricity to Gaza more water supply is [20]. The groundwater is contaminated and continuously in a huge drought due too many reasons e.g. contamination from the seawater intrusion, untreated wastewater and uncontrolled discharge from the drilled wells with no permission. Safe discharge of wastewater requires treatment to eliminate biological, chemical and physical hazards for the Gaza peoples. When the untreated wastewater and the partially treated amounts were send directly to the sea, polluted the coastline and then disturbs the fisheries [2].

Wastewater: In Gaza, the treatments of wastewater are almost missing with no improvement in reuse and the collected amount is also not significant. The total amount of wastewater produced in Gaza Strip is about 120,000 m³/day (\approx 45 million m³/yr) which distributed as North Gaza about 25000, Gaza city about 60000, Gaza middle about 10000, Khanyounis about 15000 and Rafah to the south about 10000 m³/day. The collected amount from five different plants is about 25 million m³/yr can be used for the agriculture irrigation and the 20 million m³/yr seeps to the groundwater through the leakage of the broken sanitation pipes and from the septic tanks and the rest infiltrated directly to the groundwater [2].

Most of the wastewater ponds in Gaza Strip were built in 1975 and designed for 450,000 inhabitants but Gaza is counting almost four times this population. Another problem, these ponds in Gaza were built on the sandy area which probably easily infiltrates the wastewater directly to the groundwater and contaminated it. Also these ponds are open surface which definitely increases the insects and chance for more diseases and in some cases missing its fence in which more children might fall in the collection ponds as it happened two times, last time was in 2007 when 7 children died [2].

Desalination: Several large-scale projects have been suggested but nothing happened due to political conflicts in the region and the blockade surrounding Gaza. In addition, most of the projects (desalination, wastewater treatment plants and power plant) and people's life are depending on the political situation. Six large brackish water desalination plants and one seawater desalination plant are all operating with reverse osmosis in the Gaza strip and providing 4% of the total water demand [21]. Also, there are six small scale desalination plants were

funded by Turkish government in the last few years in which they are functioning few hours per day which depending on availability of electricity and petrol. Almost 90% of the Gaza population depends on the desalinated water for drinking purposes. House unit and private desalination unit are commonly available in Gaza strip for home use production [4].

The recent solar desalination and electricity production was suggested on a land area about 13 km² to produce about 100 MCM/year and about 2500 GWh/year [22]. The problem for solar project is the huge amount of land use for example the calculated land for 1000 GWh/year is about 5 km² [23, 24]. Also the total estimated cost is between \$ 1.1 to 1.3 billion and land used is huge amount compared with other projects.

Electricity and Energy: According to the Gaza electricity distribution corporation constructive energy (GEDCO) the total available energy is about 208 MW from the needed amount of 400 MW for the Gaza peoples, in which shortage of about 48% is the demand over deficit as per April 2013. The monthly average consumption per citizen is about 50 kWh (approximately 2 kWh daily) the total customers by governorates until 31/12/2014, almost 222,000 [25]. According to the Palestinian ministry of energy and Palestinian water authority, PWA, every day needs generate the amount of electricity from the power plant about 650,000 liters of fuel, at a cost of \$500,000 US. Solar energy potential is high in Palestine in which the total annual sunshine amount is about 3000 hrs. It was calculated that the average daily solar energy varies between 2.63 kWh/m² in December to 8.5 kWh/m² in June, and average of solar radiation intensity on horizontal surface is about 5.31 kWh/m² per day [26]. This kind of technology can be used in Gaza but it needs a huge land with high capital cost.

III. PROJECT DESCRIPTIONS

Descriptions

Planning for mini projects such as desalination, wastewater collection and treatment and energy production in the Gaza Strip is urgently needed see details in Table 1. This plan could solve and/or minimize the problems of water scarce, wastewater treatment and shortage of electricity. The three different projects are related to each other which can be a complete circle that is considered as basic life for any society. Such projects can also decrease the tension in the area when providing clean environment and more jobs for the peoples living in the Gaza Strip. This kind of mini projects will be much safer than the mega or large scale projects during war and conflicts as always existing in the region.

These projects will be distributed equally all over the Gaza Strip to be able to serve maximum number of poor people including 10 vacancies each project goes to the people living in the same area. These projects can be located one each as joint project (desalination, wastewater and power plants) for the safety of land use and interrelation use of the projects. Implementations of all

projects are urgent need but also the capital cost is a huge amount of money which might be a problem to build all projects but we can distribute them into two or more groups. To start with the mostly needed area in the Gaza

Strip then step wise will complete the planned projects with respect to tariffs collection from whom able to pay.

Table 1. Mini projects details for desalination, wastewater treatment and energy for Gaza Strip.

Project Categories	Projects type		
	Desalination	Wastewater	Energy
Number of Projects	10	10	10
Total Capacity	10,000 m ³ /day	20,000 m ³ /day	10Mw/day
Total Capital cost	10M\$US	10M\$US	10M\$US
Unit cost	0.5-1.0 \$US/m ³	0.5 \$US/m ³	0.15\$US/kWh
Total Workers, persons	100	100	100

Also, the proposed mini projects plus the ongoing and existing projects in the Gaza Strip will count together about 50 to 70% from the total needed amount of wastewater treatment, energy and fresh water respectively. Although, the total cost for the proposed projects is \$ 30 million US which is high these days but with the success of this step it might be doubled the number of project and doubled the production. The success of these projects depends on the responsibility of the population towards whole system such as the used amount and the collection of the money to be able to reuse the benefits. Taking into account, some of the benefits will go to the projects components such as daily costs and/or unit cost, operation and maintenances, workers salary and rent etc.

Costs and Calculations

Bashitialshaaer & Persson has calculated from more than 20 desalination projects from different countries in the MENA region in which these results are used in Table 1. They obtained capital cost for desalination plant production is about \$ 1 million for project capacity of 1000 m³/d of desalinated water and unit cost is about \$ 0.79/m³ (approx. 4.5 kWh for 1 m³). Also, they obtained capital cost for the power plant to produce 1 MW of energy is about \$ 1 million and the average unit cost to produce 1 Watt from the power plant is about \$ 1 (approx.) [27].

The price for kilowatts of electricity in Gaza was about 0.17\$US/kWh and today the price is decreased to reach about 0.15 \$US/kWh [25]. In Gaza, the cost of water for domestic use (drinking water) varies from 5.0 to 8.0 \$/m³ for the constant amount as a specified tariff for each municipality and the exceeded amount is also varies from 0.2 to 0.5 \$/m³ in which most of this money goes to repairing and maintenance and other costs. Also, the cost of wastewater collection is about 2.0\$ for whom not exceeding the constant amount of drinking water but for people exceeding the constant amount of drinking water should pay between 15 to 40% as extra cost that calculated from the water bills total costs [28].

In general, the cost of desalinated water, treated wastewater and electricity production from the projects in the Gaza Strip can be considered as self coverage when putting everything under control and collections of payment. Some of the consumers and individual customers will have the production for free within limited amount that is depending on the income. The collected amount of

money from rest of the customers whom can pay in full should go to operational and maintenances, pre-treatment, post-treatment and workers of the projects.

The workers monthly salary for all projects can be considered as minimum of about \$ 300 and maximum of about \$ 1000 per month depending on their level of experiences such started with normal workers to expertises respectively.

IV. DISCUSSIONS AND RECOMMENDATIONS

In the Gaza Strip, electricity, drinking water and wastewater handling is the major parts to improve Gaza's people's life to being a normal human. Also, the purposes of these projects are considered positively for Gaza Strip and all neighbours that might minimize the tension and build new bridging between neighbours in the area. Moreover, environmental pollution is the main part that can effects the available water such as surface and groundwater. In the absence of stability and missing of regulations for desalination, there will be very difficult to control the quality of produced water and environmental impacts of brines. We have had very bad experience about losing projects such as airport, seaport and power plants etc., for many years which causes the funders and donors not to cooperate in the future. Also, the solar energy is not the efficient project for the Gaza case because this needs a lot of free land which is not possible [29].

Including very little collection from rain water due to high evaporation plus all available waters and desalination production the deficit is about 100 MCM/yr due to high population growth rate and the peoples in the Gaza consume today about 170 MCM/yr (90 MCM/yr for human consumption and 80 MCM/yr used for agricultural purposes). Based on 1.8 million persons and 170 MCM/yr these values make about 259 m³/capita/year, in which the WHO standard is 1000 m³/capita/year.

Wastewater reuse is very important source of water for different purposes but in Gaza Strip the total amount is about 45 million m³/yr, which make about 68 lt/capita/day (of this 25 million m³/yr can be used and losing the rest). Also, from the lasted amount direct affect goes to groundwater through the leakage of the broken sanitation pipes and infiltration from the septic tank which is considered as costlier than building an efficient collection system.

Energy and electricity is the main driving force and considered today as the worst case in the Gaza Strip because everything in our life need electricity to operate and running as normal for basic life. According to two different sources Gaza Power Generating Company (PGGC) and Gaza electricity distribution corporation (GEDCO) the deficit amount of electricity is 45 to 50 % after considering all amounts from three different places 28 MW from Egypt, 120 MW from Israeli company and 100 MW from the power generation company. Also, new projects consume a lot of energy that have to be considered in the future. In the best situation the available energy is about 208 MW (116 Watts/capita) out of 400 MW (222 Watts/capita).

With the first planned mini projects for desalination production of 10,000 m³/day, about 200,000 persons will get their 50 lt/day as fresh water and about 500,000 persons for 20 lt/day but when we increases the production peoples can get more. This distribution can function with the minimum amount until the second groups of project produces the same amount such as expansion lowering capital cost than the first groups. If we consider minimum amount of 50% collected wastewater from new desalinated amount of total 10,000 m³/day, it will make additional values of about 2 MCM/year that can be reused after treatment for different purposes.

As we mentioned before the energy projects is the most important part of this study because other projects depending on its production such as part of this energy goes to desalination plants and one to wastewater treatment plant and the rest will be used by the local customers. Other option for energy distribution is to give 100 or 200 Watts/capita from the full capacity of 10MW in the first groups, this is going to cover about 100,000 or 50,000 persons respectively. Also for double amount of energy production of about 20MW, more than 200,000 persons will get their 100 Watts and more than that number when considering family customer system than individuals.

V. CONCLUSION

In this study, introducing the mini projects solution for more safety and helping maximum number of peoples because they are almost missing everything's for many years in which this situation is negatively affecting their own daily life and thinking about the future of their children's too. I think we as the international community need to start these projects for the sake of the people's life in order to minimize the violence in the region. Also, the target of this study is touching directly to the most needed people (poorer first) in order to higher their life's standard and save their children from the available diseases.

As an engineer and researcher, such expensive projects must be safe as possible as they are related to water and energy and from my experience for Gaza strip it was horrible and still suffering because they already lost many expensive projects such as airport, water projects and power stations. These days in the Gaza Strip there are no

available areas in large scale for mega projects such as sea water desalination and solar energy station and if available it would be exposed to the bombardment and destroyed completely in once.

However, running, distribution and operational costs of these projects can be minimized by using all works and expertises from Gaza and from the same area that surrounding each project and to stress on completing the current projects, repairing the existing projects. Gaza peoples must obey the collection of tariffs from whom able to pay and then use this money for running costs and plan for the next groups of mini projects. Finally, in order to start any project and call for international funding and help, all parties in Palestine must reach a compromise.

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AUTHOR'S PROFILE



Raed Bashitialshaaer, born 1972, was living in Lund since 2006. In the last eight years worked as researcher, supervisor and teaching at Lund University in the Division of Water Resources Engineering, Center for Middle Eastern Studies and Eastern Mediterranean University in Cyprus.

I have more than 10 years of experiences in environmental research and solutions for water resources and desalination. I also have published around 40 journal articles (papers), book chapters plus so many conferences and applied for associate professor level.

My teaching experience and interests are: Environmental Science and Engineering, Fluid Mechanics, Hydromechanics, Engineering Hydraulics, Engineering Hydrology, Water Resources Engineering, Water and Wastewater Treatment Processes, Introduction to Desalination and Brine Discharge. I have worked extensively in desalination fields as an expert for more than 10 years such as brine discharge modelling and analysis of impacts especially for the Middle East region e.g. Persian/Arabian Gulf, Red Sea and the Mediterranean Sea plus written a number of papers for the Red Sea-Dead Sea Canal Project.

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