Egypt. J. Chem. **Vol. 64,** No. 11 pp. 6749 - 6759 (2021)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Application of Water Safety Plans to Improve Desalination Water Supply at Matrouh Governorate, Egypt

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Abstract

Water resources in Egypt - represented by the Nile water, renewable groundwater, and some scant annual precipitation- have been exhausted. Further development measures require a review of current water allocations in order to raise efficiencies and protect against pollution, in addition to exploring new options of nonconventional water resources to narrow the gap between water supply and demand. This paper aims to provide the steps and evaluate the impact of the implementation of WSP for a desalination supply system in Matrouh governorate, as one of the northern areas in Egypt that suffer from water shortage. Based on the outputs of the study two layers (institutional and operational) have significant improvement in terms of coordination between stakeholders internally and externally. Internally, a complete description of the water supply chain has been done that led to proper corrective actions assigned to definite members of the WSP team. Externally coordination through group meetings and negotiation has also been achieved. Finally, this research concluded that water desalination as a conventional water resource should be considered as an imperative measure for water security in Egypt. Besides effort should be done to encourage the participation of the customers which is essential in such cases of highly costly water that needs rationalization of use and cost acceptance.

Keywords: Water Safety Plan; Desalination; Institutional; Water Quality.

1. Introduction

Freshwater is the most important resource for life. Its availability enhances the quality of life and the economy of a community. Egypt has an arid climate with a lack of freshwater sources and this scarcity is expected to worsen due to global warming **(El-Sadek, 2010).**

Egypt has reached a state where the available water resources are threatened in terms of quality and quantity, this put a huge challenge on the Holding Company for Water and Wastewater (HCWW) to run and manage its Affiliated Companies (ACs) in an effective and efficient way to overcome these challenges. water companies produce on a daily basis approximately 25.1 million cubic meters of potable water serving approximately 98 million citizens mainly about 85% of drinking water is from surface water resource, 10% from groundwater resources, and 5% for desalination **(HCWW 2020).**

The per capita share already under the poverty line, in 2015, annual per capita consumption of renewed freshwater was 650 m^3, which is significantly below the 1,000 m^3/year water scarcity threshold. About 98% of Egypt's freshwater resources originate outside of its borders, such as the Nile River and groundwater aquifers. Indeed, the Nile River provides the country with some 93% of its water requirements. The total amount of deep groundwater has been estimated at about 40,000 billion Cubic Meters (BCM). The total amount of rainfall is around 1 BCM/year concentrated in the north of Egypt **(MWRI, 2014).**

The critical situation about water resources in Egypt forces the state to increase its uses from non-conventional water resources (reuse of wastewater and desalination). These resources represent 22.2% of the total available water resources. The production of desalination is calculated to be 0.5 BCM per year, according to the same strategy the amount of produced

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Receive Date: 16 May 2021, Revise Date: 02 June 2021, Accept Date: 06 June 2021
DOI: 10.21608/EJCHEM.2021.76398.3738

desalinated water will reach 1 BCM by the year 2030. Water uses and demand are figured in the following table[2].

Table (1): water resources and demand in Egypt **(MWRI, 2005).**

Resources (BCM/year)	Demand (BCM/year)
Conventional • Nile: 55.5 • Ground: 10 • Rainfall: 1 Non-conventional • Reuse: 9 • Desalination: 0.5	• Agriculture: 67 • Drinking and municipiltes:10 • Industry and electricity: 2

The Ministry of Water Resources and Irrigation (MWRI) is the ministry in charge of managing the water resources of Egypt mainly the Nile. It also manages irrigation projects in Egypt, such as the Aswan Dam and Al-Salam Canal.

Why think about desalination? There are certainly three factors: drought, climate change, and population growth **(Norling, and Masciangioli, 2004).**

Based on the fact of limited water resources desalination represent a lifeline for securing drinking water especially for the northern coastal areas. The main obstacles besides the financial difficulties i.e., low water tariff and cost of O&M, there also equally challenges in technical, legislation, and management procedures.

Water Safety Plan (WSP) represents an effective tool not only for securing the safety of the drinking water but also has a multi-impact on different sectors of the water supply system **(Abukila, 2015).**

World Health Organization (WHO) Guidelines for Drinking-water Quality stated that 'The most effective means of consistently ensuring the safety of a drinking water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. In these guidelines, such approaches are called water safety plans (WSPs)' **(Edition, 2011; WHO, 2011).**

The WSP is an approach based largely upon Hazard Analysis and Critical Control Point (HACCP) principles, a preventive risk management system developed to ensure food safety. The WHO guidelines place WSPs within a larger 'framework for safe drinking-water' that includes the public health context and health outcomes and also contains health-based targets and drinking water surveillance (Figure 1) **(Bartram, 2009).**

The outcomes of effective implementation of WSPs would increase the system resilience-based on the framework of evaluation of WSPs implementation impact will be on four different categories:

1. Institutional 2. Operational
3. Financial 4. Political

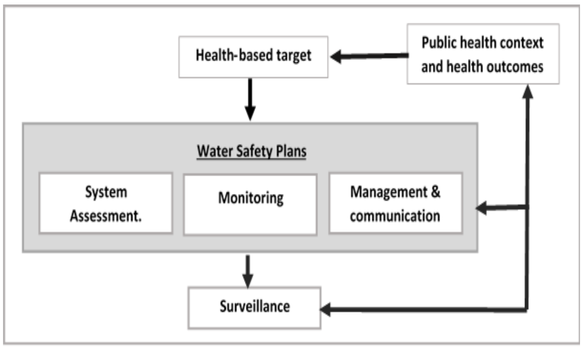

Figure (1): WSP framework according to WHO guideline, 2011

These four different layers enhance the overall system resilience. Based on the fact that the WSP implementation process is a multidisciplinary operation involves the participation of stakeholders (internally and externally). The participation of stakeholders would improve the system sustainability and the involvement of customers as a representative would increase their satisfaction and general acceptance of efforts done by the service providers.

This paper aims to provide the steps and evaluate the impact of the implementation of WSP in Matrouh Governorate.

2. Study Area.

Matrouh Governorate is one of the governorates of Egypt. Located in the north-western part of the country, it borders Libya. Its capital is Marsa Matrouh. The governorate is divided into municipal divisions with a total estimated population as of July 2017 of 429,37 **(capmas,2018).**

Figure (2): Image from Google Earth showing the location of Matrouh Governorate in Egypt.

According to population estimates, in 2015 the majority of residents in the governorate lived in urban areas, with an urbanization rate of 70.6%. Out of an estimated 447,846 people residing in the governorate, 316,005 people lived in urban areas as opposed to only 131,841 in rural areas **(WIKI, 2018).**

The North West Coast and its inland desert suffer from a fragile socio-economic structure, with a modest contribution to the country's GDP not exceeding 0.7%, although covering over 16% of Egypt's geographic area it is disadvantaged with being one of the poorest 10 governorates in Egypt **(UNDP, 2015).**

The main water source for all uses i.e., precipitation, is low and erratic – the annual long-term average is around 140 mm on the coast and up to 20 km inland, but declines drastically thereafter. The main water resources challenge in Matrouh is as follow: -

- Limitation
- Low Rainfall
- Low water use efficiency
- Shortage of water harvesting Technology **(SDCMR 2016).**

The Drinking Water and Sanitation Company was established in Matrouh in 2007 according to the decision of the Minister of Housing No. 391 in 10/23/2007 to serve the people of Matrouh Governorate. The water company serves 318,878 people in Matrouh Governorate, divided into 8 centers. The company serves 139,653 people in the center of Marsa Matrouh, and they represent 44% of the governorate's population **(HCWW, 2008).**

The average amount of water received for the governorate per day is 438,500 cubic meters, while the average amount of water received for the center of Marsa Matrouh per day is 50 thousand cubic meters per day in summer and about 30 thousand cubic meters per day in winter (This difference is the result of network infringement).

2.1. water challenges and situation description in Matrouh Governorate:

Matrouh Governorate is fed with drinking water from four sources: The total amount of drinking water used in the summer is 438,500 m^3/day from the following resources:

<u>1- South El Alamein Treatment Plant:</u>
A design capacity of 167 thousand m^3/day and a second phase is being implemented in the station to increase the design capacity to 334 thousand m^3/day.

<u>2- Kilo 40 Treatment Plant:</u>
In Burj Al Arab, where quantities of water are purchased from the Alexandria Company, reaching 180,000 m^3 / day in summer and 75,000 m^3 / day in winter

The share of Matrouh city from these two sources will be about 50 thousand m^3/day in summer and about 30 thousand m^3/day in winter. Water is transported to Matrouh via a 1000 mm diameter conveyor line and another 700 mm diameter.

<u>3- Sea water desalination units:</u> A production capacity of 856,000 m^3/day as shown in the following table:

Table (2): The desalination plants in Matrouh Governorate.

No.	The desalination plant	Capacity m3 / day.
1	Bagush	24 thousand
2	El-Nagela	2 thousand
3	The Barani	3 thousand
4	Salloum	4 thousand
5	Clio Batra	6 thousand
6	Rumaila	48 thousand

<u>4- Deep wells in Siwa:</u> The total production capacity of wells is 60144 m3/day, and 5500 m3/day is currently being used.

2.2. Rumaila Desalination System (RDS).

The main target of this study is to enhance the resilience of the water supply system of RDS. The following data in the table are essential in order to understand the context:

Table (3): Description the desalination plants in Matrouh Governorate.

1	Capacity	:	48,000 m^3 / day
2	Outlet drainage	:	150,000 m^3 / day
3	The final drainage	:	90,000 m^3 / day
4	Production of the first stage	:	24 thousand cubic meters
5	Second phase production	:	24 thousand cubic meters
6	The annual production of the station, in its two phases	:	17 million and 520 thousand m3 annually, sufficient for about 200,000 people per day.

3. Approach and methodology.

Water safety plans are the most effective way to ensure the safety of drinking water resources at all times and rely on a comprehensive approach to risk assessment and management that covers all stages of the water supply from source to the consumer **(Deere, and Dufour, 2001).**

The study includes gathering a team from the different departments concerned with the drinking water supply at Rumaila. The task force includes the operation and maintenance department, quality department, network department, planning department, and public awareness department. A meeting was held to coordinate the essential steps required to identify and quantify the hazard. A complete system description was conducted to highlight the mean potential hazard. The system description includes the following main clusters:

- Water resource
- Desalination plant
- Network distribution
- Customers community

The following activities were done in order to carry the system description. These activities were done according to WHO guidelines for Water Safety Plan Implementation **(Obeng and Awere, 2020).**

3.1. Prioritizing hazards for control.

Once potential hazards and their sources have been identified, the risk associated with each hazard or hazardous event should be compared so that priorities for risk management can be established and documented. Although there are numerous contaminants that can compromise drinking-water quality, not every hazard or hazardous event will require the same degree of attention **(Krausmann, and Salzano, 2016).**

This paper depends on assessment hazards through Qualitative description. By using risk ranking, control measures can be prioritized in relation to their significance. A variety of semiquantitative and qualitative approaches to ranking risk can be applied. Application of this matrix relies to a significant extent on expert opinion to make judgments on the public health risk posed by hazards or hazardous events **(WHO, 2016).**

3.2. Risk rating.

Table (4): Method for determining risks.

Severity rating	Four levels	Low	Medium	Very high	Very high

3.3. Field survey.

There are three types of surveys that used in the thesis to get the required information to assess the situation and the extent of WSP application in Egypt.

3.3.1. Field survey of water source.

Conducting an inspection of the scope of the environmental study for a distance of (3 km) upstream and (1 km) downstream (this distance according to the relevant regulations and laws) relative to the point directly in front of the intakes. The inspection is carried out in order to identify and allocate the potential hazards that could affect the source.

Water samples were taken from the source in order to determine the water quality, and the sampling points were also signed using the Global Positioning System (GPS) devices.

3.3.2. Study the water quality in the distribution network.

The water network is one of the main sources of dangers that must cause great tension. Therefore, the water distribution network in the study area was described and investigated through: -

- Collecting samples to check the water quality in the distribution network.
- Review the network condition and manufacturing materials.
- Water pressure in the distribution network.

3.3.3. Consumer’s Questionnaire.

The questionnaire is probably the most widely used tool for data collection. Questionnaires have been usually used in order to find facts, opinions, and views. According to **(McNeill, 1990)** there are two simple rules for success in designing questionnaires and conducting surveys: -

1. Choosing the right people to ask and having the right questions to ask them.
2. The good design of the questionnaire is the key to obtain good results and warranting a high rate of return. The most important factor of a successful questionnaire is the selection of the right people. Questions of the consumers were selected to support the subjects of the main objectives of the study.

3.3. Sample Procedures

The samples were collected according to Standard Methods for the examination of Water and Wastewater Analysis (SMWW) **(Rice et al., 2012)** and United Stated Environmental Protection Agency (USEPA) Water analysis Methods **(USEPA, 2006)** The glass and plastic containers were previously washed then stored in an ice box before delivery to the laboratory according to the limited travel timing mentioned in the standard.

4. Results and Discussions

Saline sources are different from freshwater sources in that they always require a substantive treatment step. However, while the desalination process usually provides a significant barrier to both pathogens and chemical contaminants, this barrier is not necessarily absolute, and a number of issues could potentially have an impact on public health. Some of these are similar to the challenges encountered in most piped water systems, but others, such as those related to stabilizing and re-mineralizing the water to prevent it from being excessively aggressive, are different and therefore must be addressed **(WHO, 2011).**

4.1. Implementation of WSP for RDS.

In order to evaluate the hazardous within the Rumaila Desalination System a complete investigation of the system components have been done starting from catchment ending by customers.

A) Source water and potential hazards

The desalination plant is located in Rumaila, east of Marsa Matrouh - Matrouh Governorate. The station is located at a distance of 50 to 72 meters from the coast line on the Mediterranean Sea.

Figure (3): The location of Rumaila Desalination Plant by Google Earth**.**

Due to the semi-vertical rocky nature of the coast of the project area, high above the sea water surface up to about 4 meters, consisting of limestone and dolomite to a depth of 25 meters from the surface of the earth's surface, as indicated by soil research, as well as a result of the scarcity of sediments and sedimentation due to the reflection of waves on the quasi - vertical rocky cliff The water outlet was chosen to be polyethylene pipes with a diameter of 1200 mm2, a horizontal pipe buried on the sea floor, with openings inside a cavity (tunnel) surrounded by geotextile and gravel filters to prevent any soft materials from reaching the piping openings hence the hazards of gross solids waste to adversely affect RDP.

Figure (4): The submerged intake of RDP.

The location of the outlet was chosen to be at depths of 2 meters to 2.5 meters from the marine zero in an area protected from the prevailing waves and the extreme from the northwest direction as a result of the presence of Ras Alam Al-Rum (headland). Seawater intake = 150,000 cubic meters per day.

The brine discharge point was chosen to be 200 meters east from the outlet in a way that does not allow the salty water discharged from the offshore outfall to return to the seawater intake, taking into account that the prevailing marine current is from north to south as a result of the prevailing winds from the northwest direction and also as a result of marine currents Generated by breaking waves prevailing near the coast. Offshore outfall = 90000 cubic meters per day.

Water quality at the sources was investigated via an environmental survey that covers 5 km surrounding the point of intake. Different chemical and microbiological parameters have been analyzed. The time interval is covering the year 2020. The average of these values in the twelve months is presented in the following figures

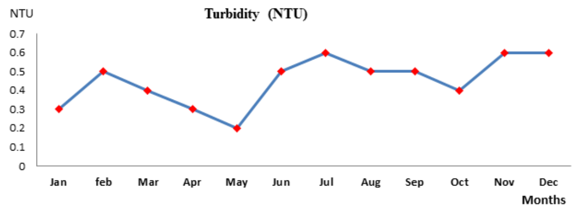

Figure (5): Turbidity monitoring for year 2020 at the water resource of RDP.

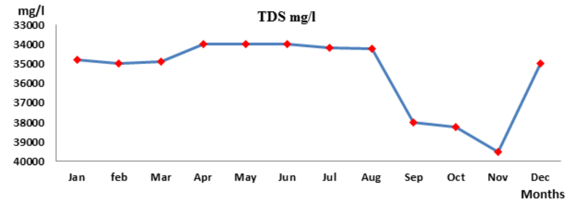

Figure (6): Total dissolved solids monitoring for year 2020 at the water resource of RDP.

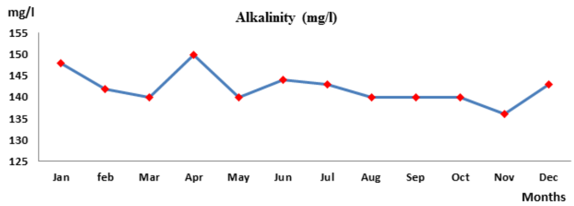

Figure (7): Alkalinity monitoring for year 2020 at the water resource of RDP.

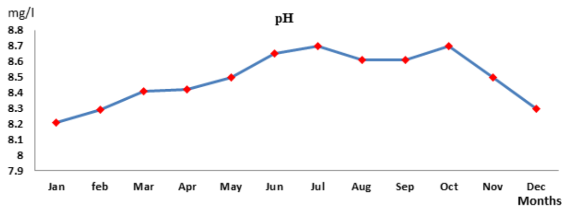

Figure (8): Hydrogen Ion concentration monitoring for year 2020 at the water resource of RDP.

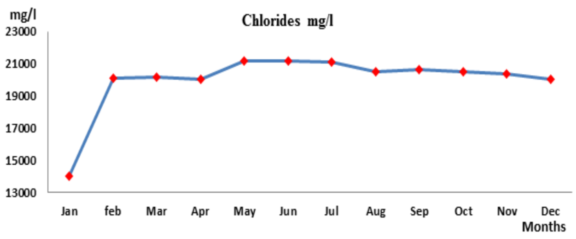

Figure (9): Chlorides monitoring for year 2020 at the water resource of RDP.

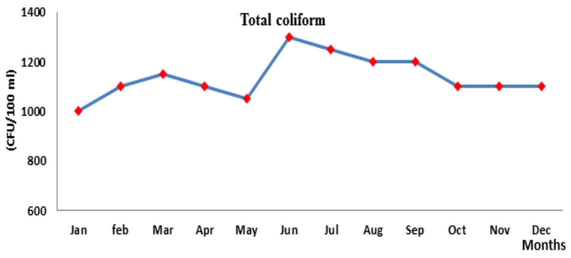

Figure (10): Total Coliform monitoring for year 2020 at the water resource of RDP.

The results of figures 5 -10 illustrate that the water quality within the study area is within the limits of the Egyptian law no. 48 for the year 1982. This kind of quality is explained that this part of the sea is characterized by a low source of pollution. Based on remote sensing the area is vulnerable to elevation level of urbanization that could be a potential source of pollution in the future as clear in figure (11):

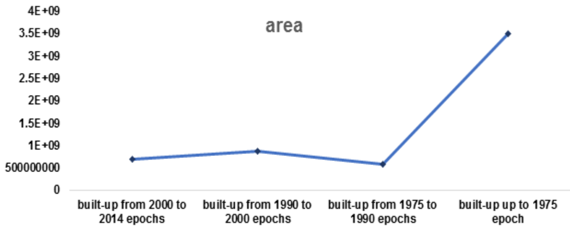

Figure (11): Degree of urbanization as showed by the geographic information system (GIS) tool.

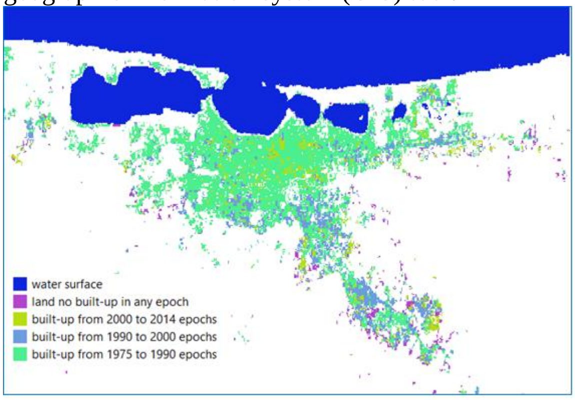

Figure (12): The map shows the degree of urbanization as shown by the geographic information system (GIS) tool.

The hazards at the water sources are illustrated in table 5, these hazards are limited to sudden accident of oil spills or discharged of human waste of the nearby communities. A qualitative risk assessment has been used as a method to prioritize the risks.

Table (5); potential hazards in water source.

Hazards	type	Risk priority	Monitoring	Corrective action
Potential leakage of raw waste from near communities	Microbiological		Field seeing Sampling and analysis	Serving the nearing communities with sanitation services + awareness campaign
Potential leakage of oils from the crafts	Chemical		Field seeing Sampling and analysis	Providing oil adsorbent material for using in emergency
Blockage of the water intake due to growth of algae	Biology		Field seeing	Regular cleaning of the intake point

B) Desalination plant and potential hazards

A WSP describe the water supply system from catchment to tap to facilitate a thorough understanding of the system, including all its steps and stages, identifies the hazards that may be introduced at each stage and determines the risks associated with those hazards. Hazards are physical, microbial and chemical contaminants that could have an impact on health or adversely affect the acceptability (e.g., taste and odor) of the water to consumers. Hazards may also be substances or circumstances that threaten the operation of the desalination plant. The risks may be the potential for a particular hazard to reach the consumer in numbers (pathogens) or concentrations (chemicals) that will result in illness or the water becoming unacceptable. This may include the risk of exceeding the current drinking-water standards in a given country. In addition to technical considerations, a WSP also entails essential management components, such as training, maintaining records, documentation and periodic review of operating procedures to enhance the operation and management of the water supply system. Table 1 illustrates the key elements of a WSP for desalination **(Tsitsifli, & Tsoukalas, 2019).**

The following diagram figure (13) illustrate the different steps of the desalination plant.

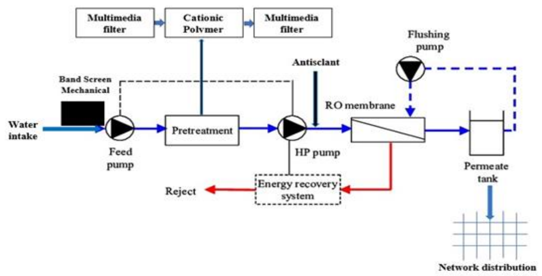

Figure (13): Layout of Rumaila Desalination Plant

The laboratory of RDP is well equipped with equipment that allows continuous and proper monitoring of the water quality. Personally, the laboratory has lacked human resources which affect the number of samples and analysis.

One of the main hazards in the desalination plant is intake blocking due to the entry of too much seaweed due to damage to the insulating layer on the intake pipes due to a design error in the outlet. The shortage of raw water supply could threaten and led to stop of the production which adversely affects the vulnerable customers. other hazards related mainly to day-by-day operations and can be mitigated through continuous monitoring. Table 6, illustrates the potential hazards at the desalination plant prioritized qualitatively and the appropriate corrective actions that will allow the sustainability of the plant.

Table (6): Potential hazards in Desalination plant.

Hazards	type	Risk priority	Monitoring	Corrective action
Blockage of the water intake due to the entry of too much seaweed (error in design)	Microbiological		Head loss monitoring	Continuous cleaning as short term+ modify the design to overcome the problem
Lak on human resources at RDP laboratory	Microbiological		-------------	Equip the laboratory with 3 chemists and 2 lab technicians

C) Distribution network and potential hazards.

RDP, in partnership with other stations (South El Alamein Water Station - Bagoush Water Desalination Station) feeds the city and networks of Matrouh, where the former water sources are supplied to the strategic tanks of the K8 lifting station and transferred to the Sereko water pumping station for distribution according to the plan set for the Matrouh water network.

Figure 14, clarify that more than 50% of the network is from asbestos which installed from more than 30 years. The other considerable percentage is for PVC. It is worth to mention that these kinds of material (iron and asbestos) together represent mor than 60 percent of the network are sensitive to the desalinated water (corrosive).

Hydraulic analysis and pressure study of the network;

Different scenarios have been studies to study the network statues as follow: -

1- current situation scenario (actual)

2- Future scenarios up to the target year.

3-Taking into consideration the entry of the authority stations and the stations that will be developed by the company.

A simulation of the study area network was made, where the following steps were taken to complete the study:

- The water Needs determined from two sources: the first source, the Egyptian Code, and the second source, the average per capita share of produced water.
- The water sources and the capacity of the stations were determined in the current situation and matched to the last update until the target year (investment plans) from the technical support, operation and maintenance sector.
- The network data obtained and updated from G.I.S management.
- Hydraulic model built and the design data for the stations were entered, as well as the data for each of (pipes and determining the age of the pipe - the valves) to simulate nature.
- The levels for the network have been entered.

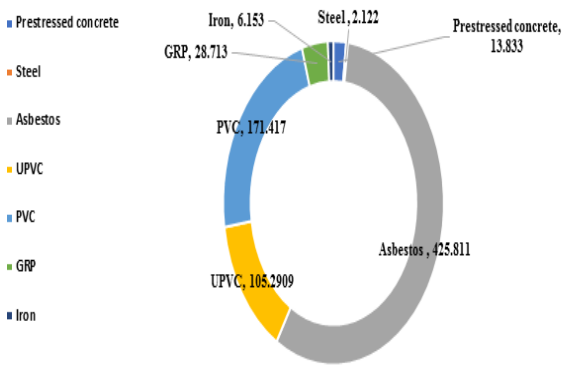

Figure (14): length (Km) and type of the distribution network.

Water supply:

The total water supply is calculated based on the actual capacity of the plants regardless the NRW. These plants are 300,000 m^3/day from South El Alamein Water Station + 60,000 m^3/day form RDP + 5500 m^3/day from ground water at Siwa Oasis. The total water supply is about 365500 m^3/day.

Water demand:

Based on the estimated population and constant water demand per capita of 250 l/cap/day. Figure (15), represent the water balance at Matrouh governorate. The main comments that the customers will be very sensitive to any delay of the needed projects.

Water projects (the policy and master planning to 2037):

The required water projects to cover the estimated water demand until 2037 is around 200,000 m^3/day produced from desalinated water. The capital investment needed to provide such amount is about 3.4 billion EGP.

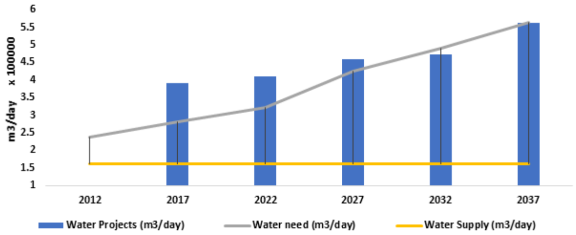

Figure (15): Water balance at Matrouh Governorate

Due to the decrease in the amount of water in the summer seasons, some citizens resort to using the ground bond that is not suitable for use due to its mixing with drainage and the high percentage of salts in it, and that is from the results of laboratory analyzes to meet the daily need of water and not taking into account the quality of the water used from the bond and the extent of its impact on public health.

The hazards within network distribution system are illustrated in table 6. Moreover, the hazards at the distribution system are the main obstacles for the sustainability of the system. Efforts should be concentrated to overcome these challenges.

Table (6): Potential hazards in Distribution network.

Hazards	type	Risk priority	Monitoring	Corrective action
Failure and fractures (high NRW) for the network due to high corrosivity of desalinated water	Microbiological		Field test (Pressure measurement – pH measurement)	Replacement of Asbestos and iron pipes
As a result of encroachments on the network and the use of the ground support and connecting it to consumers' pipes, which may cause the return of unknown source water to the network after the water is cut off.	Microbiological		Field measurement and inspection	Awareness campaign + the public authority to force the elimination of ground pumps
Low water pressure due to insufficient water compared to consumption	Microbiological		Field test (Pressure measurement)	Emergency supply by water car tanks (short term) + finish installing of the desalination projects according to schedule
frequent breaks in distribution system	Physical		Field test (Pressure measurement – turbidity measurement)	Regular network flushing + Replacement of Asbestos and iron pipes

D) Customers and potential hazards

Sometimes, as a result of consumers 'actions, the water does not comply with the drinking water standards, thus endangering consumers, including but not limited to:

- Use of alternative water sources as community stations and filters
- Connecting underground pumps to the public network.
- Storing water in unsuitable containers.
- The use of home connections that do not meet the specifications.

- Use of illegal connections (water stealth)

RDP feeds a group of estates in addition to the city with different water quality for the served area, as there are some places where the feeding is directly (Ras Alum A-Rom), which is fed directly from the RDP twice a week

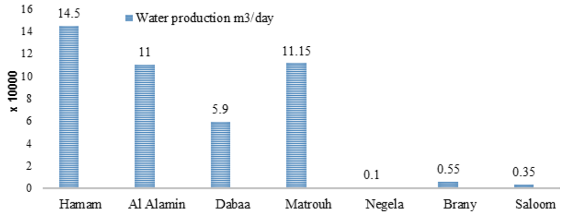

Figure (16): Water production m3/day for each district

Matrouh governorate is characterized that it's a coastal area that visited by many citizens in summer, which suddenly jump by water demand in summer as shown in figure (17).

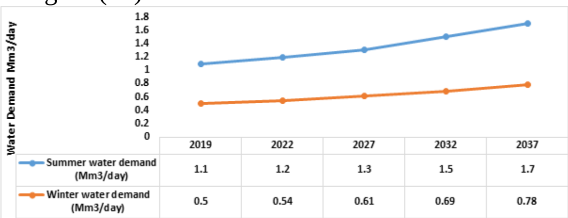

Figure (17): Difference in water demand from summer to winter season

A customer's satisfaction survey had been done to evaluate the main complains regarding the water services within the context, the main complaints from customers sides were:

- A complaint (represented 0.3%) by some subscribers who live in the upper floors of poor water and its lack of access in some cases, in relation to the areas far from the station.
- Citizens complained (represented 77.1%) about the lack of water in the summer seasons and the insufficient amount of water.
- Clients praised the water quality in the region, except for some who complained about the change in the natural specifications of the water sometimes (color).
- Some complained (represented 0.3%) about some problems related to bills and their prices.

4.2. Evaluation of the impact of implementation of WSP at RDP

In order to evaluate the impact of implementation of WSP at different layers a group of performance indicators have been calculated. Table 6, represents the evaluation of the impact based on two layers institution and operation. The value given is distributed from 0 to 4 according to the following scale:

0. No progress
1. Basic development of the WSP
2. Moderate development of the WSP
3. Good development of the WSP
4. Excellent development of the WSP

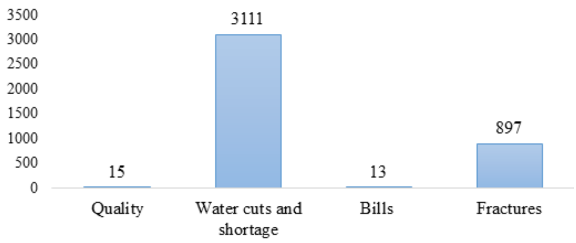

Figure (18): Type and number of complaints for 2020

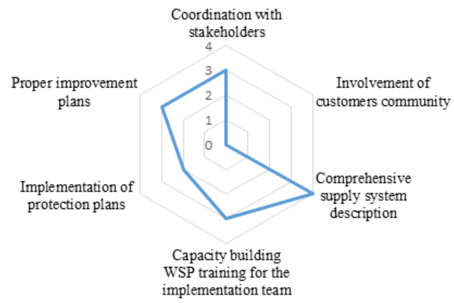

Figure (19): Evaluation of the impact of implementation of WSP

Table (7): Represents the main hazards at the customers community:

Hazards	type	Risk priority	Monitoring	Corrective action
Contamination of community ground tanks due to algal and bacterial growth	Biological		Random sampling	Adjust chlorine doses - periodic disinfection of tanks in coordination with the hotline
Pollution of internal water in homes and facilities as a result of the quality of valves and internal household connections (made of iron)	Chemical			Customers awareness about hazards associated with low quality house connections

Table (8): represents the evaluation of the impact based on two layers institution and operation

Layer	Performance indicator	value	Discussion and improve
Institutional	Coordination with stakeholders	3	Environmental Ministry-Health Ministry - Irrigation Ministry involved in 5 meetings to coordinate about RDP-WSP (Not all stakeholders are involved)
	Involvement of customers community	0	Customers are not represented so far in the implementation team
	Comprehensive supply system description	4	The supply system description covers all the supply chain
	Capacity building WSP training for the implementation team	3	Team has been trained for WSP and SSP implementation for 20 hrs./trainee
Operational	Implementation of protection plans	2	Group of SOP and monitoring procedures have been settled – lack of personal to evaluate progress
	Proper improvement plans	3	Group of well-defined corrective actions have been settled and assigned to the proper authority

5. Conclusion

Based on the results of the study two layers (institutional and operational) have significant improvement in terms of coordination between stakeholders internally and externally. Internally, a complete description of the water supply chain has been done that led to proper corrective actions assigned to definite members of the WSP team. Externally coordination through group meetings and negotiation has also been achieved. The study also concludes that effort should be done to encourage the participation of the customers which is essential in such case of highly costly water that needs rationalization of use and cost acceptance.

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