

Water Production from Seawater Multi Stage Flash Desalination Plant: A Case Study of Misurata, Libya

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Abstract: The scarcity of water resources and the increasing gap between demand and available supply in Libya is a major challenging issue facing the development sectors. Misurata is a city in the northwestern Libya, situated 187 km to the east of Tripoli and 825 km west of Benghazi on the Mediterranean coast. Most of the water resources in Misurata come along the Great Man Made River (GMMR) and some desalinated water from the Multi Stage Flash (MSF) desalination plant which lies in the border of the Libyan Iron and steel company. The objective of this research is to emphasize the vital role of seawater desalination in industry and drinking purposes. The economic aspect of desalinated water production is also covered. The objective of the research is fulfilled by collecting data about the quantity of produced water from MSF desalination plant in cubic meter per day during several years. Meanwhile, the quality of the produced water that used in both industrial and potable purpose was checked and compared with the Libyan water quality limits for industrial and potable water. Cost analysis for the produced water was prepared. The results of this research proved that the water production of the MSF desalination plant was reduced by about 23% during the period from year 2008 till year 2013 and this due to lack of maintenance. The cost of one cubic meter of desalinated water increased by about 58% during the same period due to the rise in labor's salary and cost of different input to desalination plant.

Key words: Multi Stage Flash • Desalination • Sea water • Potable • Industry • Libya

INTRODUCTION

Libya borders the Mediterranean Sea between Tunisia and Egypt. It is among the five most water scarce countries in the world and paradoxically it has the largest fossil water reserves in the world. Groundwater contributes more than 85% of Libyan water resources; More than 700 deep wells now draw water and a conveyor – the Great Manmade River Project – transfers water from these deep aquifers to the more productive coastal areas for domestic, industrial and agricultural purposes. A gap between water supply and demand will reach some 10,000-16,000 MCM/yr by 2025 [1]. Libya has a growing demand for fresh water and since 1960s has considered desalination as a sufficient solution to provide for additional water demands [2].

In Libya, the population is highly concentrated on the Mediterranean coastal zone where the climate is moderate, soils are fertile and there is presence of industrial activities. Accordingly, Libya suffers from

disparate population distribution resulting in tremendous shortage in water supply in more populated area. Many desalination plants were constructed, but some of them are currently non-operational Table 1 [3]. The total capacity of desalination water in Libya in year 2011 was 809.875 m³/day which represented 22.26% of all total renewable water resources in the country. About 26.27% or 212.538 m³/day of desalinated water is used in industry in Libya [4]. Most of the desalinated water production (about 92.44 %) is from seawater as feed water and MSF process provide 47.46% of the desalinated water production in Libya [5].

Misurata is a city in the northwestern Libya, situated 187 km to the east of Tripoli and 825 km west of Benghazi on the Mediterranean coast. Misurata has been called the business capital of Libya. Most of the water resources in Misurata come along the Great Man Made River and some desalinated water from the MSF desalination plant which lies in the border of the Libyan Iron and steel company. This company depends mainly in its production of steel

Table 1: Characteristics of desalination plants in Libya

Location	Plant type	Design capacity	No. of units	Operation year	Year of installation	Existing capacity
Derna	MSF	9000	2	1975	1973	4000
Benghazi	MSF	24000+24000	4+4	1976+1978	1974+1976	10000
Tripoli west	MSF	23000	2	1976	1974	4600
Tubruk	MSF	24000	4	1977	1975	8000
Sousa	MSF	13500	2	1977	1975	2500
Hones	MSF	40000	4	1980	1977	25000
Misurata	MSF	30000	3	1987	1982	25000
Bomba	MSF	30000	3	1988	1984	18000
Sirt	MSF	10000	1	1986	1985	9000
Zilitin	MSF	30000	3	1992	1989	20000
Tubruk	ME	40000	3		Under-construction	

on desalinated seawater from MSF plant. The objective of this research is to emphasize the vital role of seawater desalination in industry and drinking purposes. The economic aspect of desalinated water production is also covered.

Water Used in Steel Production: Continuous production of Steel and steel products is intimately connected with the availability of large volumes of a continuous and uninterrupted supply of fresh water [6]. A quantity of 100 m³ water is required for production of one ton of steel [7]. Adequate treatment of water used for both direct and indirect cooling is essential to maintain high productivity and in turn calls for specialized technologies and expertise. Continuous improvements are being made to improve the water quality used for the various applications as well as for recycling and reuse. The industry is water intensive and recovery and reuse of water has in the recent past assumed greater significance due to depleting sources of fresh water and escalating costs of water. Future efforts are needed to maximize recycle of water if the industry is to remain competitive.

MATERIALS AND METHODS

Study Area: The study area is the MSF desalination plant that exists within the border of Libyan Iron and Steel Company which located on an area of 1,200 hectares near the town of Misurata, just 210 kilometers to the east of the city of Tripoli, Libya. MSF is a method to distil sea water by flushing a portion of water into steam in multiple stages taking advantage of the fact that water boils at successively lower temperatures when pressure decreases. This process operates through a stream of heated seawater (feed water) that flows through the bottom of a vassal containing 20 chambers, stages. Each one has a slightly lower pressure than its precedent. Hot water entry from one stage to other under lower pressure boils vaporizing seawater. Afterward, the seawater circulates, on a condenser to produce pure water [5].

Two types of energy are required for the operation of a MSF desalination plant. The first is low temperature heat, which represents the main portion of energy input to the MSF and is usually fed into the system through the

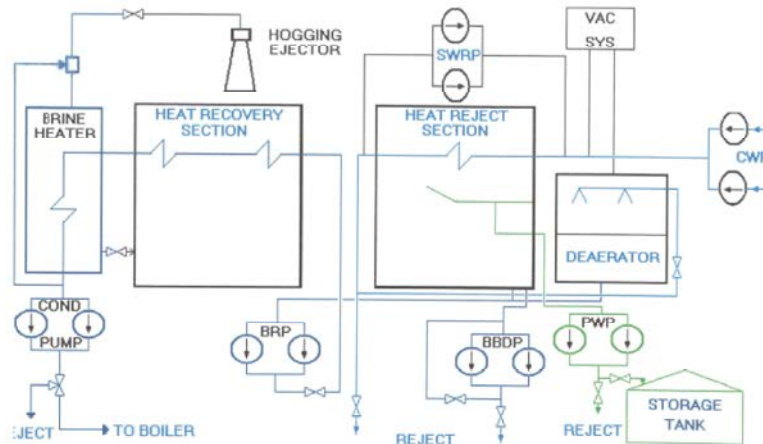


Fig. 1: Multi stage flash process

heat input section, Fig. 1. The second is electricity, which is used to drive the system's pumps. MSF desalination plant in Libyan Iron and Steel Company is an integral part of dual-purpose power/water production systems. However, low-temperature heat is usually supplied to a MSF desalination system through imported steam from the power generation plant. This steam may be extracted from the steam turbine or from the boiler after entering a pressure-reducing station. Whether the steam is extracted from a turbine or from a boiler/pressure-reducing station, it usually goes through processes of expansion and desuper heating for conditioning prior to its entry to the MSF heat input section.

Data Collection: The collected data was about sea water quality, the produced water quantity and quality for both industrial and drinking water for several years from 2005 till 2013. Data was collected about the cost of plant construction, operation cost which includes labors, maintenance, energy and chemicals cost.

RESULTS AND DISCUSSION

Quantity of Desalinated Water: The produced or desalinated water from MSF plant during the period from year 2005 till year 2013 are shown in Fig. 2. The maximum amount of water was in the year 2005 and equaled 3973275 m³ while the minimum amount was in the year 2011 and equaled 1005130 m³. The drop in the water quantity in the year 2011 was a result of the Libyan revolution in the 17 of February 2011. This means that the

produced desalinated water was about 10885 m³/day during the year 2006 and decreased gradually till about 2753 m³/day during year 2011 and then increased to about 6315 m³/day during 2012. The difference between the daily production in the year 2006 and 2012 was due to lake of maintenance and the deterioration in the plant during the Libyan evolution.

The quantity of desalinated industrial and potable water from the year 2008 to year 2013 was shown in Fig. 3 and Figure (4). During this period of time, the average quantity of the desalinated water for industry represents about 55% of the production of the desalination plant. Meanwhile, the potable water represents about 45%. Fig. 3 shows that the quantity of industrial water decreases from 7948 m³/day during the year 2008 to 5654 m³/day in the year 2010 and 2009 m³/day in the year 2012. The reduction percentage in the desalinated industrial water during the period from year 2008 till year 2012 equaled about 65% and this due to lake of maintenance.

The same trend is noticed from Fig. 4 of the desalinated potable water during the period of time from year 2008 till year 2013. The reduction percentage in the desalinated potable water during the period from year 2008 till year 2012 equaled about 62% and this due to lake of maintenance.

Quality of Desalinated Water: The Mediterranean water salinity varies along the season of the year from 38000 (PPM) in spring to 39700 (PPM) in winter [7]. The water quality parameters studied are the total dissolved solids,

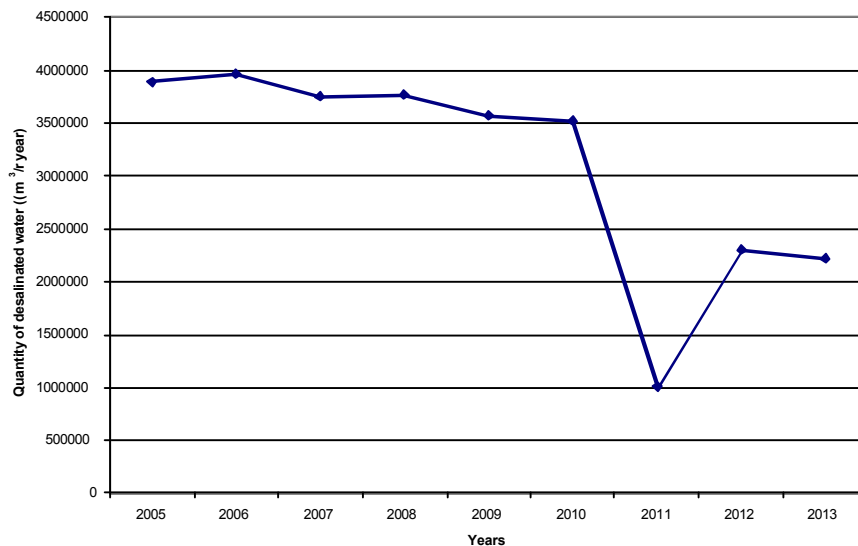


Fig. 2: Quantity of desalinated water during years from 2005 to 2013

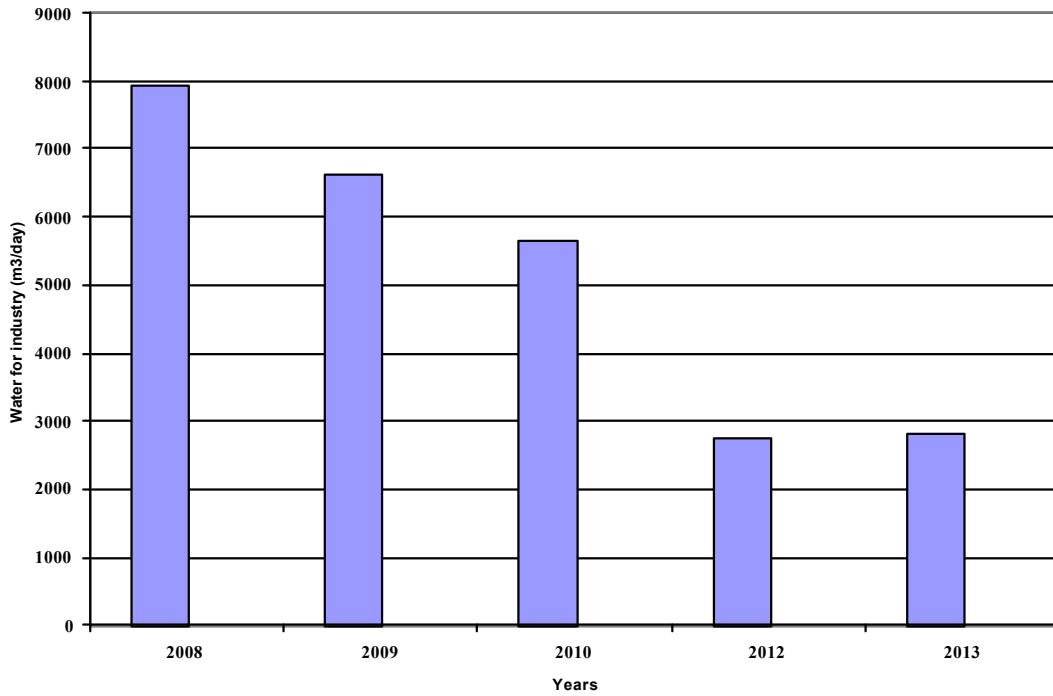


Fig. 3: Industrial water production (2008-2013)

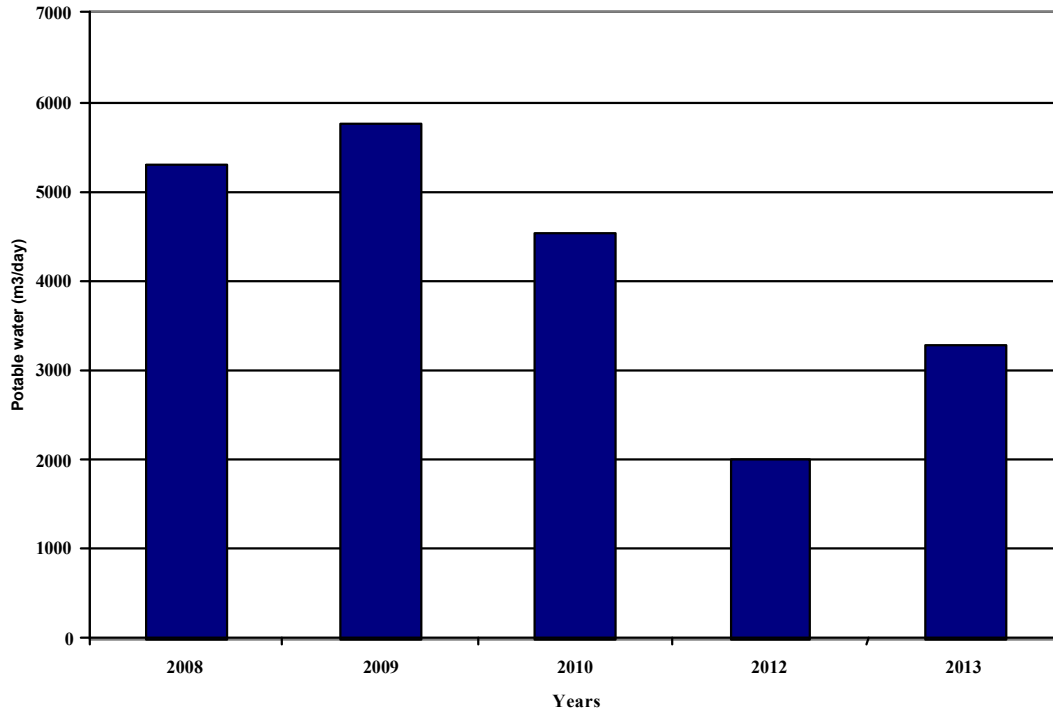


Fig. 4: Produced potable -water production (2008-2013)

total hardness and PH of both potable and industrial water. The values of the measured parameters during year 2013 were compared with the Libyan water quality Limits for both potable and industrial water as shown in

Fig. 5ab, 6ab and 7ab. It is clear from figures that the water quality of desalinated water for both industrial and potable water is within the Libyan water quality standards.

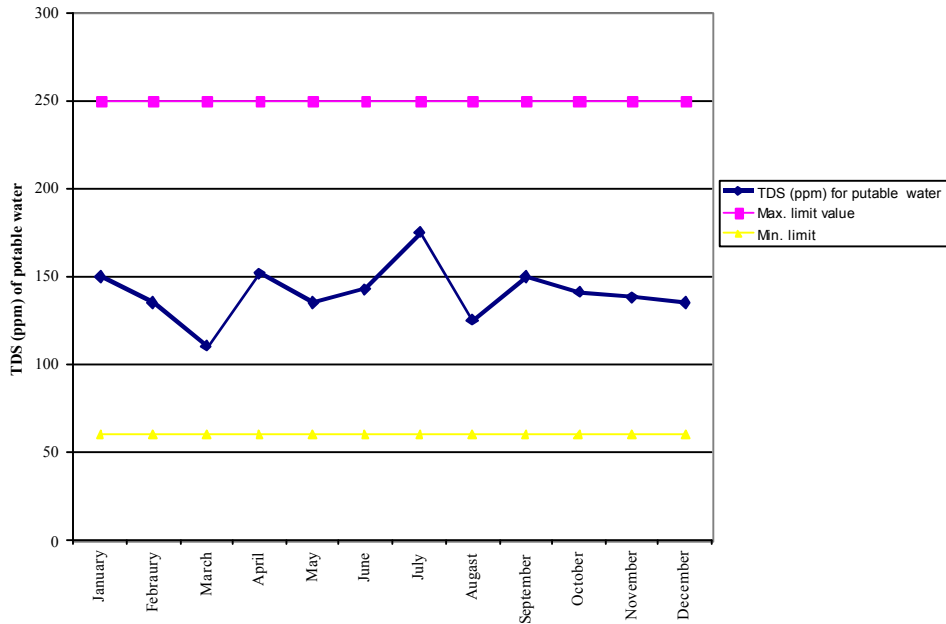


Fig. 5a: Total dissolved solids for potable water during year 2013

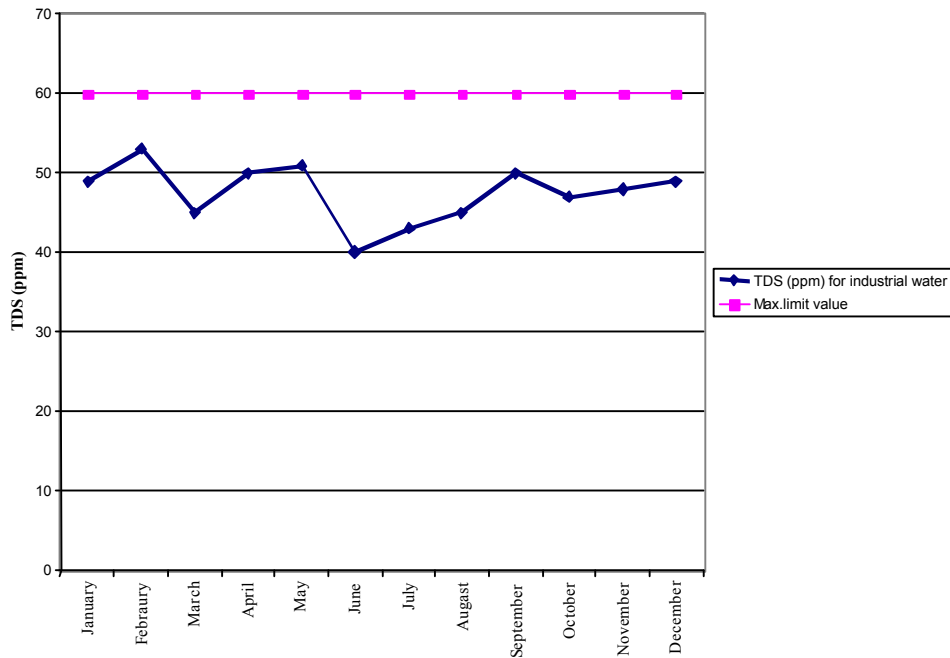


Fig. 5b: Total dissolved solids for industrial water during year 2013

Cost Analysis of Desalinated Water: The total cost of the water production from desalination plant is the sum of the capital cost and operation cost. The capital cost includes cost of construction of the plant, water intake and delivery system and mechanical and electrical installation of different machines. While the operation cost includes labors salary, oil and chemicals used, energy and

maintenance work. Fig. 8 shows the cost of the production of one cubic meter of desalinated water during the period from year 2005 till year 2013, the cost equaled about 1.1 Libyan Diner in the year 2006 and reached 1.7 Libyan Diner in year 2008 and increased to 2.8 Libyan Diner in the year 2011 as a result of the Libyan revolution in February 2011(one US dollar = 1.25 Libyan dinner).

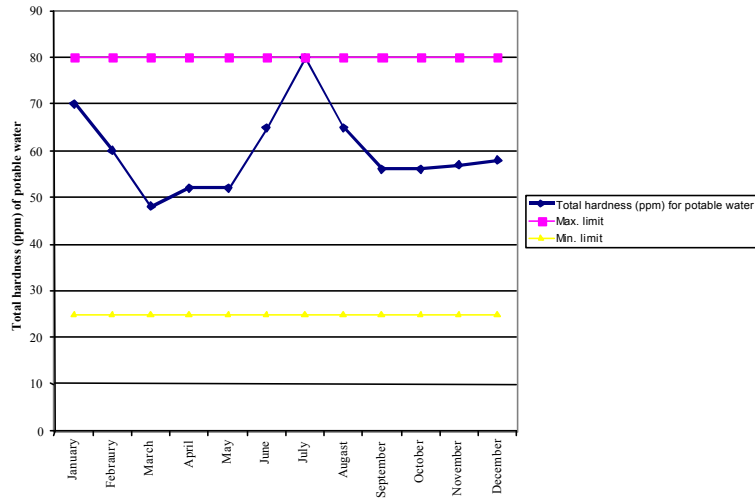


Fig. 6a: Total hardness of potable water during year 2013

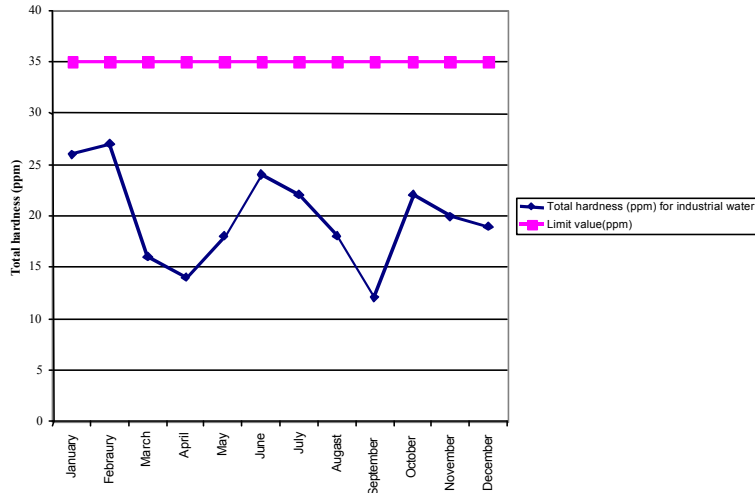


Fig. 6b: Total hardness of industrial water during year 2013

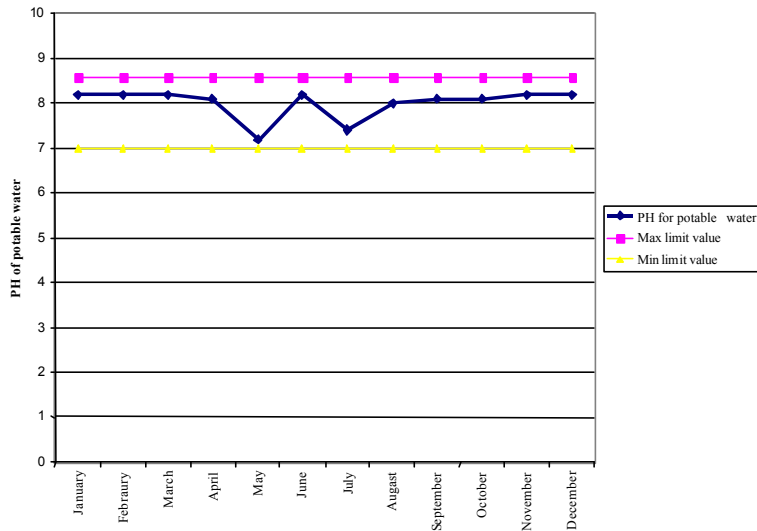


Fig. 7a: pH of potable water during year 2013

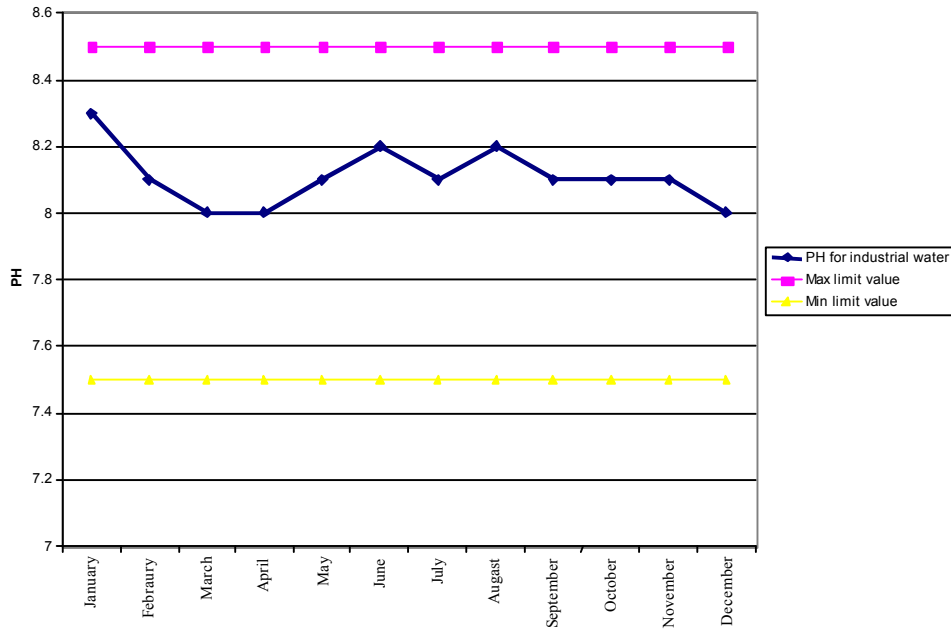


Fig. 7b: pH of industrial water during year 2013

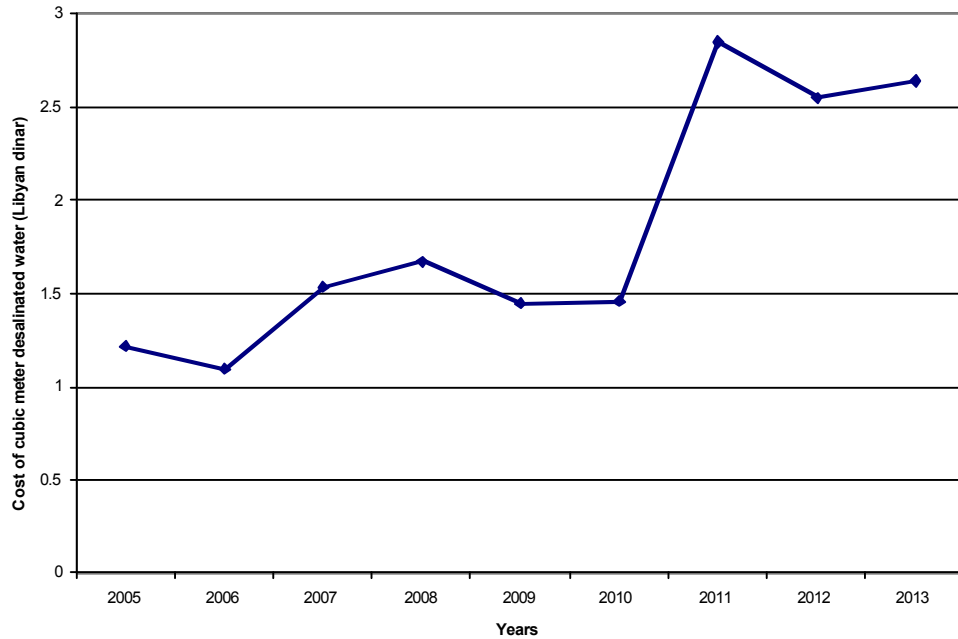


Fig. 8: Cost of production of one cubic meter desalinated water during the period from year 2005 to year 2013

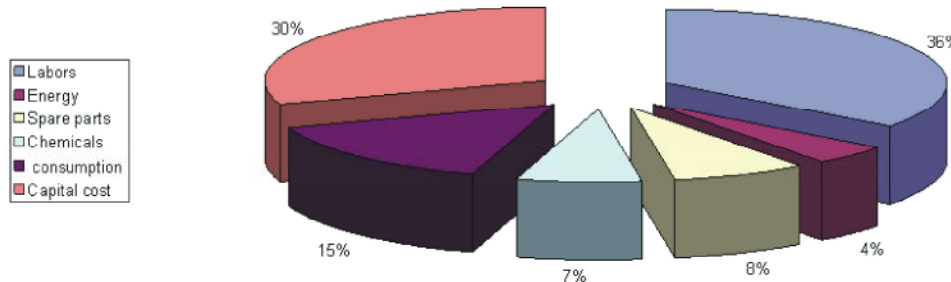


Fig. 9: Cost composition for seawater MSF desalination plant

Fig. 9 shows the composition of cost for seawater MSF desalination plant as average percentage during the period from 2005 to 2013. It is clear from the Figure that the labors cost percentage is very high, 36% in comparison with labors cost percentage that equals 7% in other countries for seawater MSF desalination plants this due high labors salary in Libya. Meanwhile energy cost percentage is very low which equaled 4% in comparison with other countries, which reach 37.6 % [9], 41% [8] and this due to abundance of Petroleum in Libya and its cheap price.

CONCLUSIONS

The results of this work proved that the water production of seawater MSF desalination plant was reduced by about 23% during the period from year 2008 till year 2013 and this due to lake of maintenance. The cost of one cubic meter of desalinated water increased by about 58% during the same period due to the rise in labors salary and cost of different input to seawater MSF desalination plant. The water quality of the desalinated water for both industrial and potable purpose comply with the Libyan water quality standards.

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