Faculty of Science - University of Benghazi

Libyan Journal of Science & Technology

journal home page: www.sc.uob.edu.ly/pages/page/77

# Assessment of brine disposal from Zliten desalination plant in marine environment

**Salah M. Algoul*[a], Abdalbaset M. Algish[b], Abdalhamed A. Musbah[c],**

[a] *Department of Chemical Engineering, Higher Institute of Engineering Technology-Zliten, Libya*

[b] *Chemical and Petroleum Department The Higher Institute for Science and Technology, Algaraboli, Libya*

[c] *Chemical Engineering Department, Awlad Ali High Institute for Science and Technology, Tarhuna, Libya*

## Highlights

- **Desalination plants cause environmental pollution of local effects.**
- **The plant is produces 30,000 m³/day of drinking water.**
- **Physicochemical analysis of different samples from brine discharge channel site were studying.**
- **Marine species are severely impacted by the brine disposal without proper treatment.**

## ARTICLE INFO

*Article history:*

Received 09 April 2018
Revised 14 December 2019
Accepted 26 December 2019
Available online 28 Dcember 2019

*Keywords:*

Desalination Plant, Environmental impacts, PH, Seawater, Salinity.

**Address of correspondence:*

E-mail address: golsasa40@yahoo.com
salah.alghoul@hpiz.edu.ly

S. M. Algoul

## ABSTRACT

Desalination plants cause environmental pollution of local effects. Disposal of desalination effluents is considered as a serious environmental dilemma. The concentration of brine varies from 50 to 75 g/L and has a much higher density than seawater and consequently tends to fall on the seafloor near the brine outfall outlet (plume effect), therefore, creating a very salty layer that can have a negative impacts on the flora and the marine life and any related human activities. In this work, we present a case study on the environmental impacts of the effluents from the MSF seawater desalination plant into a coastal and marine ecosystem of Zliten-Libya. Samples were collected from the reject channel and therefore many parameters were measured such as PH, Temperature, Salinity, Conductivity and other parameters related to seawater and produced water have been investigated too. The results showed that the pH is slightly lower than the seawater; the values range from 6.1 to 7.8. The salinity of brine discharge was found 57113 ppm compared with 35000 ppm for the seawater. The TDS of brine discharge registered 56700mg/l in comparison with 32000 mg/l for seawater, Reject brines were around 10-14°C higher than the ambient seawater temperature, which causes a negative impact on marine ecosystems.

## 1. Introduction

Many arid and semi-arid regions in the world suffer from potable water shortages, which impose constraints on economic, social and human development. Today 40 percent of the world's population, most of who live in arid countries, suffer from water shortage. This ratio expected to rise to 60% by the year 2025, due to the population growth, increased economic activities, improvements in lifestyle and increased contamination of existing water supplies (Escwa, 1996). Furthermore, severe ecosystem damage might be caused if water abstraction rates exceed natural renewal rates, leading to depletion or desalinization of stocks and land desertification.

To avoid damage for ecosystems and aquifers and to meet the growing demand, water management regimes have to increasingly implements, non-typical technologies, and source waters too. The desalination process of seawater is the technology, which used for alleviating the problem of water scarcity in many coastal regions. The worldwide production capacity forms this technology around 24.5 million m3/day (Sabine and Thomas, 2008).

Even though the desalination plants offer a range of socio-economic, human health, and environmental benefits by providing ostensibly unlimited, constant supply of high-quality drinking water without impairing natural freshwater ecosystems, concerns are raised due to potential negative impacts. These essentially attributed to the concentrate and chemical discharges, which may impair coastal water quality and affect marine life. In addition, there are pollutant emissions, which attributed to the energy demand of the processes. In fact, the lack of information on the impacts of marine discharge requires a comprehensive environmental evaluation of all major projects. A study concluded by Purnama *et al.* (2003) showed that discharging brine through a surface outfall adversely affects coastal waters and promotes saltwater intrusion.

Biodiversity monitoring data collected from the Dhkelia reverse osmosis (RO) plant in Cyprus within an area 100–200 m away from the outfall revealed that littoral flora and fauna were affected by the brine discharge (UNEP, 2003). On the contrary, a survey of the plankton community within the outfall bay of the Al-Jubail desalination plant in Saudi Arabia did not show any significant change in the distribution of phyto and zooplankton, which was attributed to the high dilution rates, attained using a 1.8 km long cascading channel (Abdul-Aziz *et al.*, 2003). The disposal of sewage water without any treatment may lead to contamination of seawater (Algoul *et al.*, 2016). In order to avert an unruly and unsustainable development of coastal areas, furthermore, desalination activity has to integrate into management plans, which regulate the use of water resources and desalination technology on a regional scale (Purnama *et al.*, 2003).

In summary, the potential environmental impacts of desalination plants should be evaluated properly, negative effects mitigated as far as possible, and the concerns that are remaining must be balanced against the impacts of alternative water supply and water management options in order to protect a sustainable use of the technology.

 ISSN 2663-1407; National Library of Libya, Legal number: 390/2018

The objective of this work is to evaluate the effectiveness of the brine or blowdown discharge, which generated from the desalination plant by taking a water distillation station in the coastal of Zliten Libya as a case study. For this purpose, the characteristics of brine discharge water, seawater intake and produced water were measured and the focuses were on the study of the temperature and salinity of brine discharge water.

## 2. Material and Methods

### 2.1. Study Area

Zliten city is situated on the Mediterranean Sea 160 km (99 mi) east of the capital, Tripoli, and about 35 km (22 mi) east of the ancient Roman city of Leptis Magna. It is surrounded by the Mediterranean from the north, BaniWalid from the south, Misrata from the east, and Khoms from the west with a population of approximately 200,000. The map of the study area is presented in Fig. 1.


**Fig.1**. Map of the study area

### 2.2. Plant description

The plant is situated at the coast of the Mediterranean Sea and produces 30,000 $m^3$/day of drinking water, which makes it the main source of drinking water for the population. Despite the plant has been running since 1991, there is no investigation of any kind to examine or evaluation of the negative impacts on the environment. Multi-stage flash (MSF) technology, which used in the plant with guaranteed restoring of more than 98% of design capacity. 3 lines à 10.000 $m^3$/d, 3 evaporator lines–each line consisting of Evaporator (22 stages), Brine Heater, A aerator, Brine Recirculation, and auxiliaries in the plant are 3 Boilers, Potabilisation Unit, Chlorination Unit, Seawater Intake, and Potable Water Supply.

### 2.3. Collection of samples

The water samples were taken on July 2017 between 8:30 am and 10:30 am in one-Liter bottles at selected sites: reject channel, collection tank (distilled water) and seawater intake. The brief details of sampling sites are presented in Table 1. Three samples were chosen randomly spaced and carried out by dipping each sample bottle at approximately 10-40 cm below the water surface by projecting the mouth of the container against the flow of the direction. Consequently, samples were transported to the laboratory suited in the city of Zliten. Temperature readings were taken on the site by using mercury in glass thermometer. Table 2 illustrate the average physical and chemical parameters of seawater intake, brine disposal and freshwater.

**Table 1**

Brief detail of sampling sites

| S. No | Site code | Description |
|---|---|---|
| 1 | Site I | Seawater intake |
| 2 | Site II | Brine discharge channel |
| 3 | Site III | produced water collection tank |

**Table 2**

Average of physical and chemical parameters of (intake, brine discharge, produced water)

| Parameter | Site I | Site II | Site III |
|---|---|---|---|
| Temperature(ºC) | 24 | 35 | 22 |
| pH | 8.1 | 8.5 | 7.8 |
| EC µs/cm | 57500 | 88000 | 608 |
| TDS (ppm) | 39700 | 60720 | 37.4 |
| Salinity(ppm) | 35000 | 57113 | 6.7 |
| Turbidity(NTU) | 0.6 | 1.1 | 0.5 |
| Alkalinity | 115 | 175 | 56.3 |
| T.H (ppm) | 4530 | 6620 | 48.2 |
| Fe (ppm) | 23.8 | 0.009 | 0.09 |
| K (ppm) | 387 | 840 | 85 |
| Na (ppm) | 10778 | 22400 | 50 |
| Ca (ppm) | 421 | 1850 | / |
| Cu (ppm) | 3.1 | 0.4 | 0.07 |
| CL (ppm) | 19444 | 31729 | 22.6 |

## 3. Results and Discussions

The results of the physicochemical analysis of different samples from the brine discharge channel site were studying and compared with the intake sweater. In addition, samples collected from the collection tank as mentioned above, compared with the world health organization (WHO) standards, and got a good result. The physical and chemical characteristics of brine discharge water, intake seawater and distillate or produced water samples illustrated in Table 2.

### 3.1. Temperature

Thermal pollution is considered one of the most major impacts of brine discharge which can occur by increasing the temperature of seawater. Numerous studies have been carried out to determine how the distribution and natural balance of marine fauna and flora species respond to an alteration in temperature (Danoun, 2007).

Multi-stage flash (MSF) plants and other types of thermal distillation tend to have the greatest impact on intake water temperature and can release brines 10 to15 ºC warmer than the sea or oceanic intake waters (Lattemann and Höpner, 2008). However, the extent of thermal impacts and distribution is influenced by the location of the plant discharge. The temperature of intake seawater was between 15 and 24 °C, while the temperature of disposal water recorded around 35 °C, which is greater than the Mediterranean sea temperature. This difference in temperature is the main reason to make thermal pollution and therefore, has aside effects on marine life. To avert the impacts from high temperatures, the outfall should achieve maximum heat dissipation by using cooling towers for instance from the waste stream to the atmosphere before entering the water body. Installing a diffuser system is considered as a good solution by mixing and dispersal of the discharge plume, as well as locating the discharge in a suitable site, which dissipates the heat load quickly. The ambient temperature for intake water reported an average value of about 24°C while the brine discharge temperature listed 35°C.

### 3.2. Salinity

Changes to salinity can play an important role in the growth and size of aquatic life and marine species disturbance. Knowledge of the limits of tolerance of marine life to different salinity degrees is an essential aspect in assessing marine disturbance and population. It can be seen from Table 2 that, the salinity of brine disposal varies from about 57113 ppm to reach the actual seawater salinity 35000 ppm in balance with the surrounding environment. The salinity level of seawater from the brine disposal is a direct function of depth (ten meters depth for instance) (Wahab, 2007), as well as the distance from the desalination charge site. To get rid of the impacts from high salinity, the desalination plant rejects stream could be pre-diluted with other waste streams where applicable, such as power plant cooling water. As regards the water from the collection tank, the salinity tabled 6.7 ppm, which is considered as permissible level according to the WHO standards.

### 3.3. Total dissolved solids (TDS)

The total dissolved solids (TDS) were the other pollutants of interest. The average Mediterranean seawater TDS (ambient TDS) 39,700 ppm, while the brine discharge from Zliten desalination plant has a concentration of TDS of 60720 ppm. The WHO standards recommended a minimum level of TDS in drinking water 100 mg/l and the maximum value of do not exceed 1000 mg/l. Samples taken from the collection tank have TDS concentration of less than 100 mg/l and registered 37.4 mg/l.

### 3.4. Electrical conductivity

The definition of electrical conductivity is a measure of the saltiness of the water and measured in micro Siemens per centimeter (µs/cm). However, typical seawater has a conductivity value of about 50,000 µs/cm and usually freshwater is between 0 and 1,500 µs/cm. The levels of intake sweater and brine discharge water were found at 57500 µs/cm and 88000 µs/cm respectively. The produced water from Zliten desalination plant has an electrical conductivity value of around 608µs/cm that considered in acceptable limits according to WHO standards.

### 3.5. Turbidity

Turbidity is a measure of water's lack of clarity. Water with low turbidity is clear while water with high turbidity is cloudy. In fact, there are many factors, which contribute to the turbidity of water. An increasing in streamflow due to heavy rains or a decrease in stream-bank vegetation can speed up the process of soil erosion. Therefore adding suspended particles, such as clay and silt to the water. The turbidity of intake site documented 0.6 NTU while the brine discharge water registered almost doubled of intake water which 1.1 NTU ppm. The turbidity of the site there showed 5 NTU, which is the same value in WHO standards.

### 3.6. Other aspects

The other big impact of brine discharge is high total alkalinity, which increases the amount of calcium carbonate, calcium sulphate and other elements of the seawater. During the present study, the total alkalinity registered 115 mg/l and 175mg/l for intake seawater and brine discharge water respectively. The pH range of marine environments is also changing due to the brine discharge too but that is very negligible in comparison with the other impacts (Skinner, 2008). To get appropriate equality of water, the pre and post-treatment processes are required whereby many chemicals are added such as ant scaling and antifoaming agents, which are discharged with brine and affect the marine species around the outlet (Medeazza, 2005).

## 4. Conclusion

Desalination projects cause many negative effects on the environment. The disposal of the brine discharge is one of the major environmental concerns associated with the desalination process. Some of the most significant impacts are those associated with seawater intake and brine disposal. This work focuses on brine disposal impacts, describing the most important aspects related to brine behavior and environmental assessment, from Zliten seawater desalination plant (ZSWR). The major concern of these impacts surrounds the outfall brine discharge because of its physical and chemical features. High salinity, high temperature and high total alkalinity of the discharge brine could have several positive and negative impacts on the surrounding environment. Thermal and saline pollution caused by desalination projects and these environmental problems have localized effects. These might cause damage to marine life in the desalination intake or disposal vicinities. Marine species are severely impacted by the brine disposal without proper treatment. It is important to decrease this environmental damage by reducing desalination plant temperature differences in any proper way, by cooling for example. Other negative aspects of desalination needed to study such as high-energy usage and GHG emissions, which are much more significant relative to the impact of brine. Regarding regulations, the authorities should establish new legislation regulating brine discharges, which includes emission limit values and quality standards in the environment.

## Acknowledgment

The author would like to thank all members in Zliten MSF desalination plant for their assistance during the course of this study.

## References

Escwa (1996) 'Economic and Social Commission for Western Asia and UNEP United Nations environmental program', Proc, Expert Group Meeting on the Implementation of Agenda 21 for the integrated water management in the ESCWA region, United Nations, New York, 1996

Sabine, L. and Thomas H. (2008) 'Environmental impact and impact assessment of seawater desalination', *Desalination*, 220, pp. 1–15

Purnama, A., Al-Barwani and Al-Lawatia, M., (2003) 'Modeling dispersion of brine waste discharge from a coastal desalination plant', *Desalination*, 155, pp. 41–47.

UNEP/MAP/MEDPOL, (2003) Sea Water Desalination in the Mediterranean: Assessment and Guidelines, MAP Technical Reports Series No. 139, United Nations Environment Programme (UNEP), Mediterranean Action Plan (MAP), Programme for the Assessment and Control of Pollution in the Mediterranean region (MEDPOL), Athens, Greece, 2003.

Abdul-Azis P. K., Al-Tisan, I. A., Daili, M. A., Green, T. N. Dalvi, A. G. I. and Javeed, M. A., (2003) 'Chlorophyll and plankton of the Gulf coastal waters of Saudi Arabia bordering a desalination plant', *Desalination*, 154, pp. 291–302.

Algoul M. S., Moftah Bozakaya, Mohamed Derenesh, Abdulah Alhdaar (2016) "The study of the impact of sewage disposal of marine pollution in the beach of Zliten city-Libya" "paper presented at the Conference: 1st International Conference on Chemical, Petroleum, and Gas Engineering ICCPGE 2016At: Al-Mergib University Alkhoms Libya.

Danoun, R. (2007) Desalination Plants: Potential impacts of brine discharge on marine life, University of Sydney, Sydney, Project Report.

Lattemann, S. and Höpner, T. (2008) 'Environmental impact and impact assessment of seawater desalination', *Desalination*, 220, pp. 1-15.

Wahab, S A (2007) 'Characterization of water discharge from two thermal power/desalination plants in Oman', *Environmental Engineering Science*, 24, 3, pp. 321-37.

Skinner, L. (2008) Review of Literature on the Effects of Desalination Plant Brine Discharge Upon Cetaceans, report no.R1339, URS Australia Pty Ltd, East Perth.

Medeazza, G. L. (2005) 'Direct and socially-induced environmental impacts of desalination', Desalination, 185, pp. 57-70.