

## Study of dispersion of brine water into coastal seawater by using a pilot

L. Habet\*, K. benrachedi

Laboratory of Food Technology, Faculty of Engineering Science, university of Boumerdes Algeria.

\*Corresponding author: [benrachedik@yahoo.fr](mailto:benrachedik@yahoo.fr)

ARTICLE INFO	ABSTRACT / RESUME
<p><b>Article History:</b></p> <p>Received : 11/01/2015</p> <p>Accepted : 11/04/2015</p> <hr/> <p><b>Key Words:</b></p> <p>Desalination, Environment,</p> <p>brine, sea water, pilot.</p>	<p><i>Les technologies utilisées dans le dessalement des eaux de mer sont accompagnées par diverses impacts sur l'environnement. Plusieurs effets considérés dans les unités de dessalement tels que les impacts marins et la pollution marine. Les unités de dessalement des eaux de mer sont localisées pour apporter un supplément d'eau aux populations et aux diverses applications. La construction des unités de dessalement et les infrastructures installées sur les côtes affectent le milieu marin. La grande salinité de la saumure et les produits chimiques utilisés sont déversés dans le milieu marin. Ainsi, plusieurs impacts sont causés par la décharge de la saumure. Dans cet article, l'objectif de ce travail consiste d'étudier l'influence de différents paramètres de dispersion de la saumure comme la position du rejet, le déplacement et le temps. Différents points de rejet de la saumure (P1, P2, P3) sont étudiés horizontalement et verticalement en fonction de la température de l'eau de mer. Les résultats expérimentaux obtenus montrent que la dispersion de la saumure, la meilleure position est celle la plus lointaine et la plus profonde (P3).</i></p> <p><i>The technologies used in water desalination are accompanied by adverse environmental effects. There are several effects to be considered in desalination plants, such as the use of the land, the groundwater, the marine environment and noise pollution. Seawater desalination plants are located by the shoreline, to supply desalted water to the population of the main cities and for other uses. The construction of both the desalination plants and all the required infrastructure in coastal areas affects the local environment. For instance, the high salt concentration in the brine and several chemical products used in the desalination process are returned to the sea. Most impacts on the marine environment arise as a consequence of the brine discharge. In this paper, the objective of this work consists to study the dispersion of the brine discharges and its impact into marine environment. Then, a pilot used to study the different parameters of dispersion such as position of brine and depth and time of dispersion. Different points of brine (P1, P2, P3) were studied horizontally and vertically according to the ambient sea water. Experimental results obtained show that dispersion of brine in best then position of brine point is far and in down sea (P3).</i></p>

## I. Introduction

Algeria with a semi-arid climate and with its limited water resources already intensively utilized, suffers from temporary water shortages, with a high level of utilization of its water resources, water demand increasing due to repeated drought. The government of Algeria has decided to construct a number of desalination plants based on reverse osmosis. Reverse osmosis is a physical process in which contaminants and the undesirable compounds are removed by using pressure on the feed water by forcing it through a semi permeable membrane [1]. Provision of potable water by seawater desalination is generally considered a benefit despite high construction and operating costs of plants. This is especially true when conventional sources of freshwater are absent or cannot be exploited without severe environmental damage. Whoever is familiar with the situation in arid countries such as Algeria knows that desalination plants are often large industries facilities, which consume space and emit substantial amounts of combustion gases. It is also knows that potable water production means emitting a concentrate into the sea or into the ground. However, a generally less noticed fact is that this concentrate contains not only the contents of the seawater taken in, but also additives necessary for the desalting process and corrosion by products [2, 3]. The response of the impacted marine ecosystem depends on its sensitivity [4] and the magnitude of the impact, which in turn depends on factors such as distance, transport direction and dilution. Most impacts on the marine environment arise as a consequence of the brine discharge and its effects could be worse in the Mediterranean sea than in other areas. So our purpose is to study desalination of sea water impact into marine environment, using a pilot dispersion of brine into marine environment.

## II. desalination of sea water impacts into environment

Desalination of seawater is thus the technology predominantly used for alleviating the problem of water scarcity in coastal regions. Although desalination of seawater offers a range of human health, socio-economic and environmental benefits by providing a seemingly unlimited, constant supply of high drinking water without impairing natural freshwater ecosystems, concerns are raised due to potential negative impacts. These are mainly attributed to the concentrate and chemical discharges, which may impair coastal water quality and affect marine life, and air pollutant emissions attributed to the energy demand of the process. The list of potential impacts can be extended, however,

the information available on the marine discharges alone indicates the need for a comprehensive environment evaluation [5, 6].

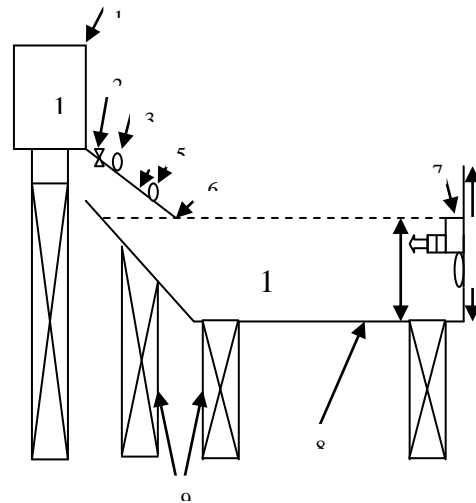
## III. Matériel et méthodes

### 1. Study of dispersion for brine into laboratory pilot

The brine is a reject of desalination process. The high salt concentration in the brine and several chemical products used in the desalination process are returned to the sea. In our research, we have studied specially dispersion or propagation of brine into sea water by using laboratory pilot which is constituted by a sea water basin and a reservoir of brine (see figure 1)

### 2-Experimental work

We have used in this study the following laboratory pilot :



**Figure.1:** pilot experimental and his accessories

#### Legend :

- 1- graduated reservoir of brine (volume = 10 liters)
- 2- control valve of brine flow
- 3- flow to measure reject flow
- 4- conduct of reject in glass or plastic (PVC) diameter d= 5mm
- 5- Manometer to measure reject pressure
- 6- Position of reject point (variable)
- 7- ventilation point
- 8- graduated tank of sea water (volume = 760 liters in glass)
- 9- Metallic supports
- 10- brine
- 11- Sea water

### 3. Analysis Method :

#### 3.1. brine and sea water preparation

To study the brine discharge propagation in seawater, we have used concentration equal at 60 g/l. , salinity of sample for sea water at 32 g/l (temperature ambiente = 15° C).

Then, we have considered constant flow and pressure of brine reject.

#### ➤ Experimental Conditions

- ❖ Sea water ambient
- ❖ Time of dispersion for brine is 20 minutes.
- ❖ Reject flow  $Q_R = 0,15$  l/min.
- ❖ reject pressure for position ( $P_1$  et  $P_2$ ) = 0,07 bar
- ❖ reject pressure for position ( $P_3$ ) = 0.1 bar

#### ➤ prepared volumes

$V_{\text{brine}} = 10$  liters

$V_{\text{seawater}} = 300$  liters

### 3.2. Experimental protocol and operation mode :

- 1- placing brine and sea water in the tank successively in the basin.
- 2- Opening the valve (2) for a constant flow.
- 3- Monitoring over time and space :
  - For different positions for reject point (6), we measure :
  - changes in salinity in the basin according to the time and the directions (x,y,z) ; salinity (t,x,y,z)

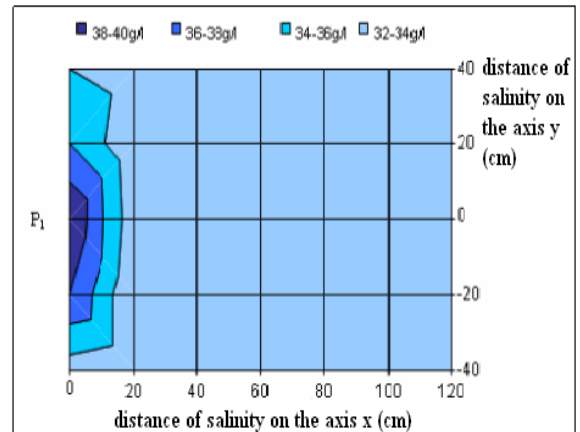
### 3.3. Point reject situation :

**Table 1 : Rreject points situation**

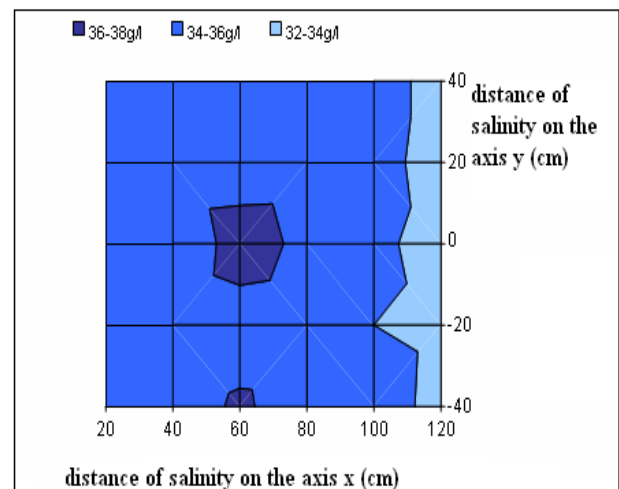
Positions	sampling on the axis z ( depth, surface level)
$P_1$	- at surface level. - at 10cm below - at 20cm below
$P_2$	at 20cm below
$P_3$	at 20cm below

## IV. RÉSULTAT ET DISCUSSION

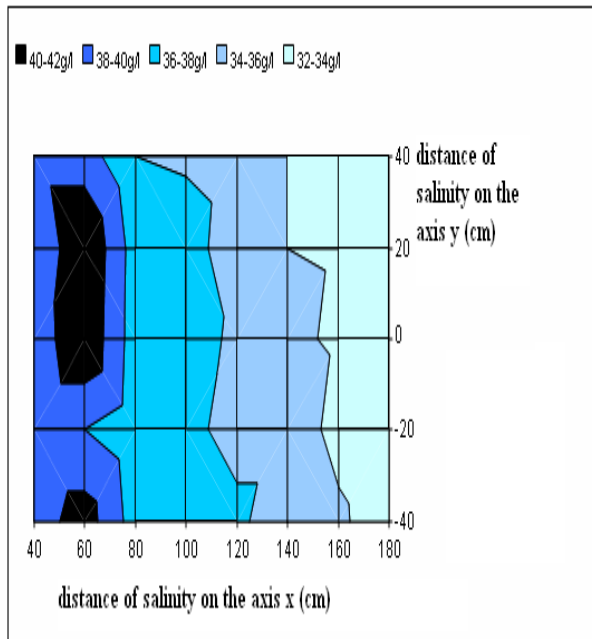
### 1. dispersion of brine in the sea water according to the depth of the basin



**Figure 2 :** evolution for the salinity of brine discharge into seawater in the basin area at  $P_1$ , with sea water stable according to distance and time ( $x, y, z=0, t=20$  min).



**Figure 3 :** evolution for the salinity of brine discharge into seawater at depth 10 cm in the basin at  $P_1$  with sea water stable in function ( $x, y, z=10$  cm,  $t=20$  min).



**Figure 4 :** evolution for the salinity of the brine discharge of seawater a depth of 20 cm in the basin at  $P_1$ , with seawater stable in function  $(x, y, z=20 \text{ cm}, t=20 \text{ min})$ .

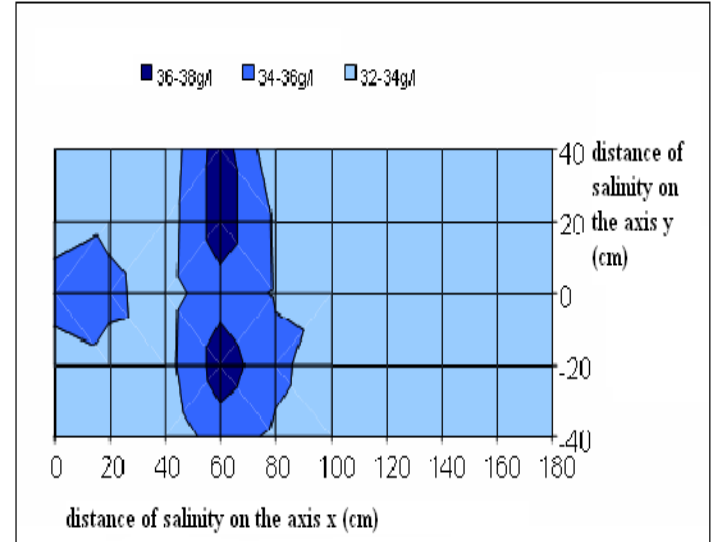
From the results shown in the figures 2, 3, 4, we observe that the point of brine discharge, salinity is too high. It decreases in sea surface from 10 cm on axis  $(x)$ , this has been shown by the work of J.J. Malfeito and al. [7] in the channel Fantana desalination plant in Javea in Spain [7]. However, it forms a plume at the bottom of the sea which becomes highly saline with a concentration 42g/l. This is due to the difference in density between the sea and the brine. Then extends to a distance of 120 cm. So, it causes ongoing damage to the aquatic flora and fauna, especially in the coastal marine inhabitants.

For instance, and based on the work of Jacqueline L Dupavillon and al.[8] brine concentrations 50 g/l have an inhibitory effect on the growth and development of embryos apama of Sepia, and on microscopic bacteria or fungi pathogens.

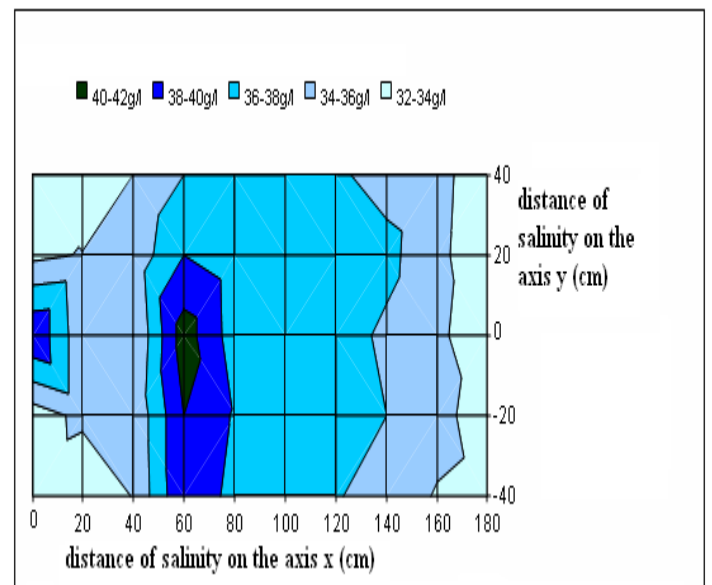
## 2. Propagation of brine discharge of function time

(sampling at depth 20cm)

❖  $P_1$  : position of reject point on coastal



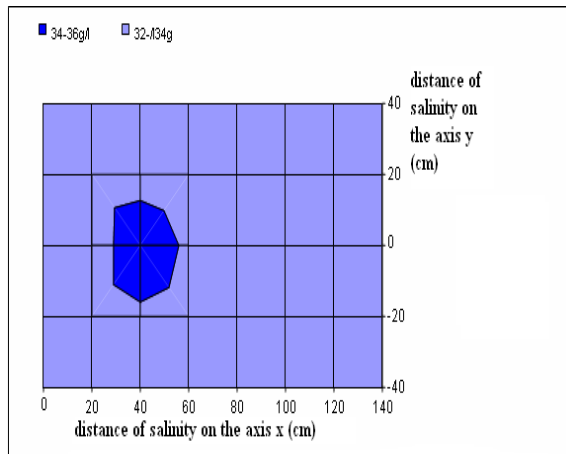
**Figure 5 :** evolution for salinity of brine discharge into sea water in the basin at  $P_1$ , with sea water stable in function  $(x, y, z=20 \text{ cm}, t = 10 \text{ min})$ .



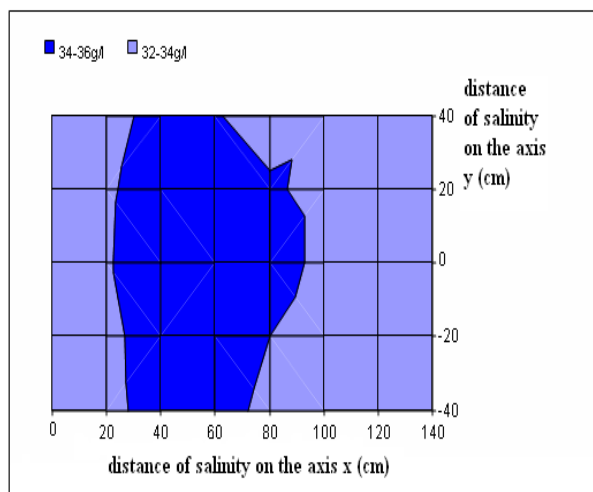
**Figure 6 :** evolution , function de  $(x ; y ; z=20 \text{ cm} ; t= 20 \text{ min})$ , salinity of the brine discharge on the sea water in the basin at  $P_1$ , with seawater stable

We observe from the results shown in figures : 5, 6 a gradual increase in salinity in the basin over time. Indeed, the value of the salinity of seawater recorded after 20 min brine discharge reaches a maximum value of 42 g/l. This is due to obstacles located at the bottom of the basin. This high salt concentration can affect the local marine inhabitants. Indeed, these comments were raised by the work of Jacqueline L Dupavillon and al.[8].

❖ **P<sub>2</sub> : position of reject point 40 cm far for cosatal**



**Figure 7 :** evolution of salinity of brine discharge on the seawater in the basin at P<sub>2</sub>, with sea water stable in function (x,y,z=20 cm, t=10 min).

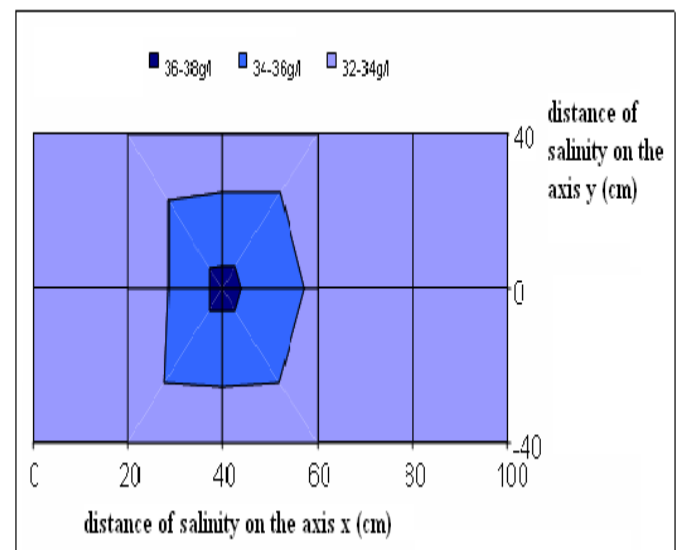


**Figure 8 :** evolution of salinity of the brine discharge on the seawater in the basin at P<sub>2</sub>, with seawater stable in function ( x , y , z = 20 cm , t = 20 min).

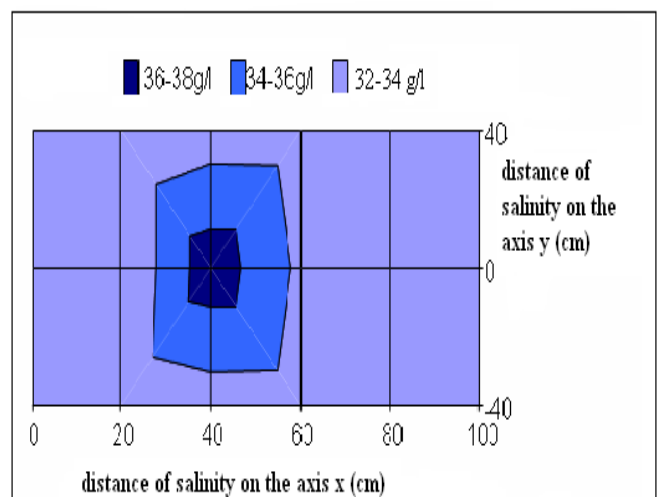
We observe from the results shown in the figures 7, 8 the salt concentration is still high at the discharge point and extends over time. The brine can go further but at low concentrations. This is due to the great depth from the point of discharge. According to the work of Villanueva R. and al.[9] growth rates of cephalopods are affected by the low concentration of salinity, from where low salinity brine increases the size of statolith. But also causes

deformities of embryos. This comment has been removed by the work of Paulij, W.P and al. [10] According to R. Einav [11], category where worked on the same conditions, no overview of environmental impact was observed in the region of Malta (personal information Domovic Darko).

**P<sub>3</sub> : position of reject point 40 cm l far for coastal, situated at bottom basin**



**Figure 9 :** evolution of salinity for brine discharge into sea water in the basin at P<sub>3</sub>, with sea water stable in function ( x , y , z = 20 cm , t = 10min ).



**Figure 10 :** evolution of salinity for brine discharge into seawater in basin at P3 with seawater stable, in function (x; y; z=20cm; t=20min).

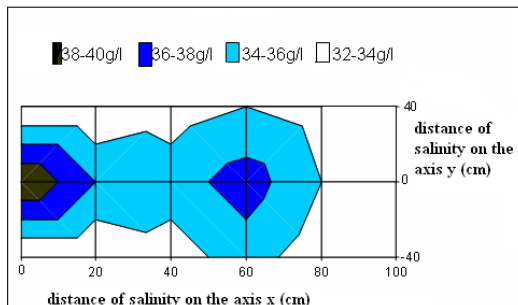
We note from the results shown in the figures : 9, 10 salt concentration is still high at the discharge point. It decreases with time. For the discharge of the brine discharge forms a jet of water, due to the pressure  $P' = 1,2 \text{ bar}$  ( $P' > P$ ), and the inclination of the discharge point upwardly at an angle  $30^\circ$ . This corresponds to a rapid dilution. In fact, these comments were raised by the work of T. Bleninger and al. [12].

According to the work of R. Zimmerman [13] which he worked on the same conditions, the jet of brine has a well-defined area (depending on the flow and speed of the jet). The current density of the jet can cause erosion at the bottom, this implies the difficulty of stabilizing grass prairies and aquatic vegetation (studies in the Canary Islands – the region of Sardinia Del Norte)

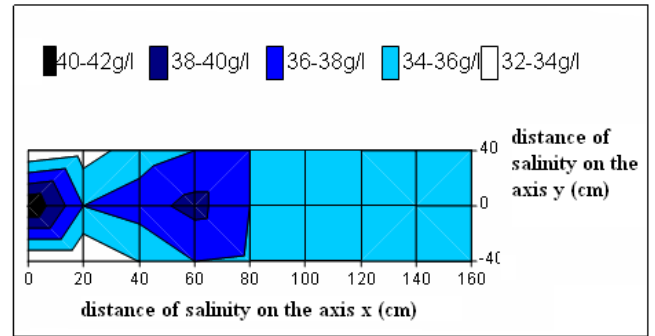
Sandy deposits removed by the phenomenon of erosion can fill the holes of the rocks, which are an important marine habitat for different fish, decreasing it with disappearance of aquatic vegetation and benthos.

### 3. Effet on temperature on propagation of brine into sea water in function time (sampling at profundity 20cm)

❖  $P_1$  : position of reject point on coastal



**Figure 11:** evolution for salinity of brine discharge into sea water in the basin at  $P_1$ , with sea water stable at temperature  $T=25^\circ\text{C}$  in function (  $x, y, z = 20 \text{ cm}, t = 10 \text{ min}$ ).



**Figure 12 :** evolution for salinity of brine discharge into sea water in the basin at  $P_1$ , with sea water stable at temperature  $T=25^\circ\text{C}$  in function (  $x, y, z = 20 \text{ cm}, t = 20 \text{ min}$ ).

We noticed from the results shown in the figures: 11, 12 that the diffusion of brine is faster at  $25^\circ\text{C}$  compared to  $15^\circ\text{C}$ , so we can say that according to the results of Ahmed. Hashim and al. [14], Gulf countries:

- the increase in temperature of the brine typically causes an increase in temperature of the sea water, which can directly affect the marine organisms in the discharge zone.
- We go more over, the high temperature process can affect water quality and consequently, decrease the concentration of dissolved oxygen in seawater

## V. Conclusion

Seawater desalination is a solution to the growing demand for freshwater, but the used technical processes could damage the environment, with impacts such as the global warming due to the increases use of energy, noise pollution, negative effects on land use and adverse effects on the marine environment. Brine reject is always the main environmental problem and his discharge is usually done jointly with the discharge of waste water treatment, thus diluting it. There are some marine species affected by the salinity of the brine discharged into the sea, as grass prairies. In this paper, the work is intended to contribute to the study of the impacts of seawater desalination on the marine environment in the Mediterranean through the use of a pilot spreading brine on sea water and its effect on marine environment.

The study of the propagation of brine seawater as a function of time, we concluded that total



calm sea water, brine goes to the seabed, as it provides a source of continuous and cumulative pollution, it would result in ongoing damage to the flora and fauna in the vicinity of the discharge point, and would be linked to the increase of the salt concentration and temperature. Since the Mediterranean is characterized by its great depth, the dilution is faster. It is therefore desirable to place the brine discharge point far from the beach (sample P3) and rocky areas which are rich in organisms

Perspective, it would be interesting to install diffusers on channel rejection, the performance of the operation depends on the number of broad casters and the space between them.

They will improve the dilution.

Another option is the use of lenses pointing at an angle of 30-90 ° to the seabed, so that the concentrated brine is pressed in the direction of the surface of the sea.

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