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The Environmental Impact of Water Intakes and Discharges for Desalination

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***Abstract*—Desalination is a viable solution to meet the increasing demand for fresh water in coastal areas. However, the main challenges that affect desalination are its impact on the environment and energy consumption, which can lead to high costs. Direct seawater intake is the most commonly used extraction technique, but it has several drawbacks such as ecological impact, corrosion, fouling, intake clogging, operational hazards, and regulatory compliance. To minimize these challenges, boreholes for seawater collection have emerged as an alternative to direct seawater intake. The advantages of boreholes include reduced impact on marine life and the environment, consistent water quality, increased reliability, reduced maintenance costs, and avoidance of coastal modifications. The only disadvantage is that drilling wells for seawater extraction can be challenging if the permeability of the soil is low, which may result in a limited flow rate. Despite this, the use of boreholes for seawater collection can help minimize the impact of desalination plants on the marine environments and provide a reliable and consistent source of seawater for the desalination process.**

***Keywords*— desalination, environmental impact, water intakes, environmental regulations**

I. INTRODUCTION

Water is essential for animal life and ecosystems. Only 2.5% of all water on the planet is fresh water, found in the form of ice caps and glaciers, groundwater, and surface water, much of which is not suitable for human consumption or crop irrigation. The global population increases every day, and with it the intensive demand for water, given that water is a finite resource [1].

The world's population has steadily increased, reaching 8 billion people in 2022, a figure that is projected to reach about 10 billion by the year 2050 [2]. This population growth is expected to widen the gap between rich and poor, as well as between regions affected by climate change and global water scarcity. Today, more than 2.3 billion people live in countries with water stress [3].

Surface water and rainfall resources are becoming increasingly scarce in many regions of the planet, which makes the desalination of seawater or brackish water a viable alternative to meet the planet's growing freshwater needs, despite the fact that it requires energy consumption, which should ideally be supplied by renewable energy. Desalinated water has been shown to be an excellent source of water for industrial processes that require high-quality water, and it is also a good alternative as the only possible option in many regions of the world [4-6].

In desalination projects, one of the fundamental aspects to take into consideration is the systems for collecting the water to be desalinated. The correct selection and design of these systems is fundamental for the proper operation of the desalination plants, which is the main objective addressed in this work.

The research issue discussed in this paper is important because water scarcity is a growing concern worldwide, and the demand for fresh water is increasing due to population growth, climate change, and other factors. The desalination of seawater or brackish water is a potential solution to address this challenge, but it requires careful consideration of various factors such as energy consumption and water collection systems. By focusing on these issues, this research can contribute to the development of more effective and sustainable solutions for meeting the world's growing freshwater needs, particularly in regions affected by water scarcity. Overall, this research issue is crucial for addressing one of the most pressing challenges of our time and ensuring a sustainable future for all.

The article discusses the challenges associated with direct seawater intake for desalination, and explores the use of boreholes as an alternative method for seawater collection. The main objective is to highlight the advantages of boreholes over direct seawater intake, such as reduced impact on marine life and the environment, consistent water quality, increased reliability, and reduced maintenance costs. Overall, boreholes offer a viable solution to minimize the impact of desalination plants on the marine environment, and provide a reliable source of seawater for the desalination process.

II. WATER INTAKES FOR SEAWATER DESALINATION.

In seawater desalination projects, water collection is a fundamental aspect for the proper operation of the desalination plant, as it supplies the plant's demand flow. Designers have to guarantee that the water collected is seawater with an electrical conductivity of around 50,000 μΩ/cm, at a temperature of 25ºC [7-8].

Seawater collection can be done in two ways.

a) Direct seawater intake.

b) Boreholes for seawater collection.

There is also water from the subsoil, which is categorized as brackish water. Water, with certain chemical characteristics, once infiltrated in the rocks, can undergo complex and drastic modifications to its physical, chemical and biological composition as a consequence of its interaction with the environment. The changes to the composition of the water will depend on the duration and location of the interaction. This interaction with the environment sometimes causes the conductivity of the water to reach values of up to 5,000 μΩ/cm, which makes it unfit for human consumption, and agricultural water is considered brackish water [9].

The following is a description of the different types of seawater abstraction that exist to supply desalination plants.

2.1. Direct seawater intake.

Direct seawater intakes are piping systems that connect the desalination plant directly to the sea [10]. The diameter of this pipe will be sized according to the flow rate demanded by the plant. This type of intake is the most suitable when a hydrogeological study advises against seawater intake by means of wells.

The most singular elements that make up a direct seawater intake are:

Water intake tower or caisson.

The water intake tower or caisson is the element located at the end of the seawater pipeline, attached at a certain depth. It consists of a box, which can be made of different materials, polyester, polyethylene or concrete, with circular or rectangular water inlet windows, protected with grids to prevent the entry of fish or solids. The windows are located on the sides of the caisson, and as far away as possible from the seabed, to avoid entraining sand from the seabed due to water suction. Horizontal water entry into the caisson is more advisable than vertical water entry, as it reduces the intake of organisms. The number of windows is determined by the flow demand of the desalination plant, taking into account the load losses caused by the windows and grids, as well as any other element that could interfere with the water intake. The structure of a tower or water intake box can be seen at: https://www.iagua.es.

The seawater intake caissons are constructed dry, then transported and anchored. The caissons can be self-floating or transported by inflatable floats. They are transported to the selected location in favorable weather and wave conditions using a tugboat. Once at the selected location, the caisson is sunk in a controlled manner to the selected coordinates and levelled perfectly. Prior to anchoring, the need to provide a support bench or to anchor it in the existing ground has to be assessed.

Seawater intake with subsea emissary

One or more intake pipes have to be installed from the seawater intake box to the desalination plant. The main challenge in designing the intake pipes is the environmental factors affecting the design due to their impact on the marine ecosystem.

Intake pipes can be designed mainly in the following ways: trench installation method, which involves dredging the seabed to place the pipeline in the trench, although this method has a significant impact on the marine environment; other methods with less impact on the marine environment include micro tunnels, directional drilling, and pipeline ballasting.

The pipe selected for seawater transport is usually made of polyethylene due to its flexibility and ease of installation. Polyethylene outfall installation (https://siecsa.com).

2.2. Boreholes for seawater collection.

As stated in [11], seawater collection by means of boreholes consists of drilling one or several wells close to the coast, generally at a distance of less than 100 m. Fig. 1 shows the different parts of a borehole, which is comprised of a casing, screen, and filter pack. The diameter of the borehole must be between 350 mm and 600 mm, and it should be constructed with a casing to prevent collapse and contamination.

In boreholes for seawater collection, the pump's suction surface is installed inside the borehole at a level below - 40 m.a.s.l., which stands for meters above sea level and refers to the elevation above the average sea level.

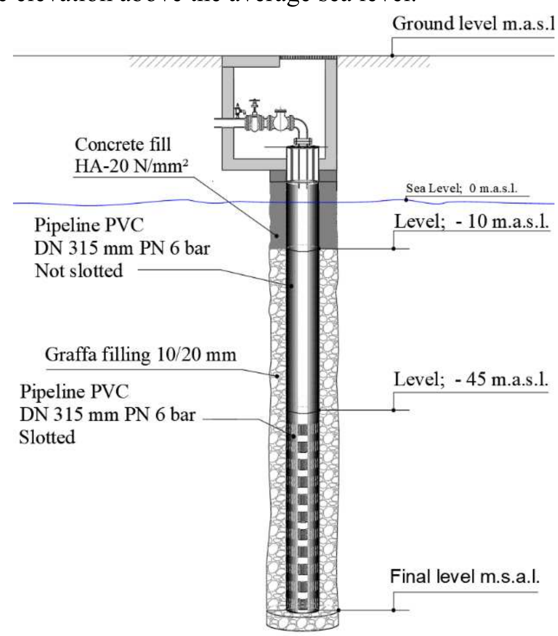

Fig. 1. Borehole construction detail.

To prevent the walls of the borehole from collapsing and causing entrapment, a polyvinyl chloride (PVC) pipe with nominal diameters between 300 mm and 500 mm is installed along the length of the borehole.

The PVC pipe is slotted from -40 m.a.s.l. to allow seawater to enter for impulsion. The space between the pipe and the borehole walls is filled with gravel as a filtering element from the lower level of the borehole up to -10 m.a.s.l. The maximum size of the aggregate must be 76 mm (sieve 80 UNE 7-050 ISO Standard), and its granulometric composition will be determined based on the characteristics of the land to be drained and the drainage system. From -10 m.a.s.l., the space between the pipe and the borehole walls is filled with mass concrete (Common Cements UNE 80-301, Cements for special uses UNE 80-307 ISO Standard). This is to prevent possible contributions of surface water from runoff, which could alter the conditions of the seawater to be desalinated and vary the initial design parameters of the seawater captured. The concrete components, dosage, manufacturing process, and transport must comply with the requirements of the EHE, PG 3/75, and subsequent approved modifications.

2.2.1. Justification of the depth to be reached by the boreholes.

To ensure that the water being taken in is salt water, we must take into account the depth relative to the water table. If we make the assumption that fresh water and salt water are two separate fluids that cannot be mixed, there will be a boundary between them in the form of a sloping interface, which can be described using mathematical formulas.

The saltwater front can be visualized as a tongue that moves inland during times of low aquifer recharge and recedes towards the sea during periods of high recharge due to the slope of the interface. However, it is important to note that seawater and fresh water are not completely immiscible, and mix in a region known as the mixing or transition zone. The change from one fluid to the other is gradual in this zone, which is also referred to as the diffusion or transition zone.

Specific gravity:

- Fresh water: 1,000 g/cm^3.
- Salt water: 1,025 g/cm^3 on average, varying according to salinity and temperature between 1,020 g/cm^3 and 1,030 g/cm^3.

Viscosity:

- For the same temperature, seawater has a 30% viscosity higher than fresh water.

Salinity:

- Seawater: 40-45 g/L.
- Rainwater:
- Average Cl- ion value: 0.3-3 ppm.
- Cl- ion value in the vicinity of the coast: 10-40 ppm.
- Cl- ion value at 50 km inland: 20 ppm.

Using the Ghyben-Herzberg equation [12], the hydrostatic equilibrium between fresh water and salt water is determined by considering them as two immiscible fluids, i.e., without mixing, and separated by an interface.

The development of the Ghyben-Herzberg postulates is based on the static equilibrium of two columns of water of different density, Fig. 2.

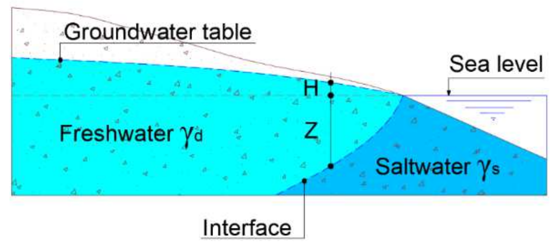

Fig. 2. Fresh water – salt water equilibrium under hydrostatic conditions.

To apply the formulation, the following considerations are taken into account:

- Existence of hydrostatic equilibrium between the fluids.
- The separation surface between fresh water and salt water is flat.
- There are no vertical load gradients.
- There are no head losses of the seawater as it moves inland.

If the two fluids in question were not in hydrostatic equilibrium under these conditions, the interface would be horizontal and therefore the fresh water would be, at any point, floating above the salt water due to a simple difference in density.

Based on these assumptions, equilibrium occurs when:

$$\gamma_d\,(H+Z) = \gamma_s\,Z$$

where:
γ_d: density of fresh water (1,000 gr/cm^3)
γ_s: density of seawater (1,025 gr/cm^3)
Z: depth of the interface with respect to sea level.

Therefore:

$$\gamma_d\,(H+Z) = \gamma_s\,Z$$

$$1{,}000\ (gr/cm^3) * H + 1{,}000\ (gr/cm^3) * Z = 1{,}025\ (gr/cm^3) * Z$$

$$1{,}000\ (gr/cm^3) * H = 1{,}025\ (gr/cm^3) * Z - 1{,}000\ (gr/cm^3) * Z$$

$$1{,}000\ (gr/cm^3) * H = 0{,}025\ (gr/cm^3) * Z$$

$$Z = \frac{1{,}000\ (gr/cm^3)}{1{,}025\ (gr/cm^3)} * H = 40 * H$$

That is, for each meter of fresh water above sea level at a given point, the interface is at a depth of 40 m.

This value is obviously approximate and varies between 50 m and 33 m for seawater densities between 1.020 and 1.030 gr/cm^3.

The wells are usually within 100 m from the coastline, so the height of the water table with respect to sea level (H) is around 20 cm. Therefore, placing the seawater intake at a depth below -40 m.a.s.l. guarantees that the freshwater aquifer will not be affected and ensures the capture of seawater.

2.2.2. Drilling techniques for boreholes.

These boreholes can be drilled by means of percussion or roto-percussion machinery.

The process of drilling boreholes using percussion involves utilizing a specialized bit known as a percussion bit, which comes in varying diameters, ranging from 350 mm to 600 mm, and has an approximate weight of 5 to 6 tons, as illustrated in Fig.3.

Fig. 3. Drilling machine. Percussion piece, bit.

The preparation of the work area will only consist of installing the drilling machine. The machine has support legs that can be adjusted in height depending on the terrain, leaving the drilling machine level and secure on the ground to be drilled.

The technique of percussion drilling involves dropping the drill bit from a specific height, ranging from 5 to 15 cm vertically, and with a frequency that varies based on the composition of the ground being drilled. As the bit strikes the ground, it fractures it, and water is simultaneously introduced into the borehole. This water mixes with the fragmented ground, resulting in the formation of drilling mud [13].

After drilling to a depth of roughly 2.0 meters, the drilling process continues as follows: the bit is retracted to insert a mud withdrawal valve (shown in Fig. 4). The mud removal valve is composed of a metal pipe that extends approximately 4.0 meters in length, featuring a non-return valve. This valve is inserted into the sludge under its own weight, allowing the sludge to enter the pipe. Once the valve is full, it is extracted from the borehole, and the sludge is emptied into a designated sludge pond.

The mud valve is inserted several times to ensure that all the mud is removed. Once this is done, the drill bit is reinserted to continue the process.

Drilling with broken-percussion.

Rotary percussion drilling involves a combination of rotational and percussive forces in order to achieve optimal results. The drilling diameters associated with this technique are typically smaller than those used in traditional percussion drilling, ranging from 180 mm to 450 mm, as depicted in Fig. 5 [14].

Fig. 4. Sludge removal valve.

The drill cuttings are usually extracted by introducing a fluid through the internal part of the drill string, which then rises up the borehole, dragging the crushed material with it.

Roto-percussion drilling offers the benefit of higher drilling efficiency when compared to traditional percussion drilling techniques. However, it requires the use of more specialized equipment with smaller drilling diameters than those used in percussion drilling. It is important to note that roto-percussion drilling is not recommended for extremely fractured terrain, which represents a significant disadvantage.

Fig. 5. Drill head with roto-percussion.

2.3. Brackish water intakes

Groundwater abstractions with conductivity greater than 3,000 μΩ/cm can be considered brackish water due to its high electrical conductivity. This high conductivity makes it unsuitable for human consumption or agricultural use.

This is due to the fact that rainwater, with certain chemical characteristics, once infiltrated into the rocks, can undergo complex drastic modifications in its physical, chemical and biological composition as a consequence of its interaction with the rocky environment. The modifications in the composition of the water will depend on the time and space of the interaction [9].

Groundwater collection in free or confined aquifers is carried out by drilling wells, whose drilling technique is the same as for seawater collection wells, by means of percussion or roto-percussion machinery.

III. SEA BRINE WATER EMITTERS

Once seawater has been desalinated to produce fresh water in a desalination plant, which has a fresh water production rate of around 35-40%, the brine must be returned to the marine environment. This brine represents about 60 to 65% of the water that enters the plant.

When designing the brine discharge into the sea, it is necessary to characterize the effluents of the rejection, characterize the receiving environment, predict the behavior of the discharge by means of its dispersion plume, as well as assess the environmental impact on the marine environment in order to establish corrective measures.

As shown in Table I, this brine has a higher ion concentration, on the order of 1.6 to 2.5 than the extracted water, and is higher in temperature. The increase in ion concentration due to brine discharge can cause an osmotic imbalance in the marine environment into which it is discharged [15].

Marine phanerogams, specifically oceanic Posidonias, are the most sensitive to changes in ion concentration, which makes this aspect important in the discharge of brine. Research has shown that this species is susceptible to environmental changes in regions near underwater pipelines, particularly at salinity levels between 38.4 g/L and 39.8 g/L. Such changes can result in a decline in stem count, leaf size, and other anomalies [16].

The behavior of the effluent when brine is returned directly to the sea depends on the discharge system used. These are usually classified into two groups: those that discharge the brine over the coastline and those that discharge it with an outfall on the seabed. The advantage of the former is that they can be built on land, which avoids the environmental impacts, dangers, insecurity and high costs that are involved in marine works, but they have the disadvantage that it is more difficult to achieve the required dilutions. Therefore, the former is more economical, but less efficient in achieving the dilutions [17]. Another way of dumping whose advantages and disadvantages we will analyze in this paper is the use of brine dumping wells.

The main methods for dumping brine directly into the marine environment are the following:

- Direct surface
- On riprap
- With outfall or discharge pipe
- With diffusers
- With ejectors

3.1. Direct surface brine discharge

As its name suggests, this is a direct discharge on the sea surface. The problems posed by this type of discharge are, on the one hand, that the brine sinks rapidly, causing low dilution. On the other hand, the dispersion plume spreads over long distances, posing a threat to the health and survival of phanerogam meadows. Its advantage is that it is an easy and economical work to build on land.

TABLE I. PROPERTIES OF SEAWATER AND BRINE

Brine			**Seawater**		
pH		6.56	pH		6.78
Conductivity μΩ/cm		99891	Conductivity μΩ/cm		49500
Turbidity (NTU)		0.21	Turbidity (NTU)		0.21
CATIONS	mg/l	meq/l	CATIONS	mg/l	meq/l
Na+	28,154.0	1224.09	Na+	12,157.0	528.57
K+	925.0	23.72	K+	410.0	10.51
Total	29,079.0	1247.80	Total	12,567.0	539.08
ANIONS	mg/l	meq/l	ANIONS	mg/l	meq/l
Cl-	49,000.0	1380.28	Cl-	21,200.0	597.18
SO4-	8,000.0	166.67	SO4-	3,600.0	75.00
NO3-	11.4	0.18	NO3-	5.3	0.09
Total	57011.44	1547.13	Total	57011.44	1547.13
STD	86,090		STD	37,372	
OTHER			**OTHER**		
Si	0.4 mg/l		Si	0.1 mg/l	
Fe	0.02 mg/l		Fe	0.01 g/l	

3.2. Dumping in breakwater

In the case of brine discharge in a breakwater, it is necessary to study the swell at the discharge point. The problem is that during a period without waves or with low waves, the brine solution will be highly concentrated, resulting in a variable dispersion plume depending on the intensity of the waves. As an advantage, the brine discharge site is inexpensive to construct on land and is relatively easy to implement.

This brine discharge system consists of placing a discharge pipe at a certain distance from the coast. This brine discharge system has a high dilution, which results in a low risk to phanerogam meadows.

However, the brine discharge system using discharge pipes entails a high cost, since it requires not only the installation of the discharge pipe, but also auxiliary parts such as nozzles and diffusers. It also has a greater impact during the construction phase.

3.3. Discharge of brine to borehole

According to the Ghyben-Herzberg formula, the brine discharge point should be located at a level below -40 m.a.s.l. Therefore, a discharge pipe must be installed inside the well, and the diameter of the pipe and brine flow rate has to be determined.

The construction characteristics of the brine discharge borehole are identical to those of the seawater intake borehole. This brine discharge system is very efficient, as it provides high dilution and creates a low risk to phanerogam meadows. Moreover, drilling a brine discharge well does not entail a high cost [18,19].

However, one of the disadvantages of the underground brine discharge system is the high cost associated with installing the discharge piping, nozzles, and diffusers. Additionally, the construction phase can have a greater environmental impact.

IV. ENVIRONMENTAL LEGISLATION AND REGULATIONS APPLICABLE TO GROUNDWATER INTAKES FOR DESALINATION IN THE EUROPEAN UNION, THE CASE OF SPAIN.

The entry of Spain into the European Union became effective in 1986, and since then, the rules and legislation implemented on Spanish territory must strictly comply with European protocols, rules, and laws. Desalination projects are no exception, and to comply with European regulations, the following aspects must be completed prior to execution:

- Environmental impact studies (biotic and abiotic environment).
- Studies of discharge alternatives (outfall, mixing with wastewater, etc.).
- Discharge dilution models and the use of scale simulations.
- Study of effects on species (Posidonia oceanica).

Posidonia meadows are included in Annex I of Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora.

All elements in contact with seawater must be suitable for human consumption and not have elements in their composition that can migrate into the water, according to RD 140/2003 of February 7, 2003, which lays out the sanitary criteria for the quality of water for human consumption.

Appendix A shows the legislation and environmental regulations applied to brine emitters in Spain in concordance with European regulations.

V. DESALINATION IN THE CANARY ISLANDS, SPAIN.

The Canary Islands region is a global leader in the production of fresh water from seawater in, and a reference point globally for its expertise with different desalination technologies. Currently, through desalination, the islands produce around 121 hm^3 of fresh water per year, which represents 19% of the total water consumption required for the archipelago [20].

In islands such as Lanzarote and Fuerteventura, desalinated water is practically the only source that supplies fresh water to the population and tourism. In the past, during periods of drought, the water in these islands was supplied by marine vessels. This share reaches 99% in Lanzarote, 86% in Fuerteventura, more than 50% in Gran Canaria and 9.0% in Tenerife [6,20].

Fresh water on the islands comes from groundwater, regenerated water or desalinated water. At present, groundwater on all the islands in the archipelago is overexploited, so desalination is the most viable alternative to increase the volume of fresh water for public and agricultural supply.

Desalination on the islands has increased significantly in recent years due to the rising water needs of the growing tourist population. This tourist population is mainly concentrated on the coast, so seawater desalination has become the best way to increase the volume of fresh water.

The disadvantage of desalination in the Canary Islands, which are of volcanic origin with a very steep orography, is that the cost of supplying the population at an elevation above 250 m.a.s.l. is disproportionate in terms of the price per cubic meter desalinated, due to the high cost of pumping from the desalination plants, which is in addition to the already high production cost per m^2 of desalinated water.

In the Canary Islands, the most commonly used method of seawater collection and brine discharge is the drilling of boreholes. This is due to the fact that the Canary Islands Network of Protected Natural Spaces, the Canary Islands Network of Biosphere Reserves and the large number of protected species are so extensive that seawater abstraction and brine discharge by drilling boreholes is the least environmentally damaging system [21].

VI. DISCUSSION.

Direct a seawater intake involves pumping seawater from the ocean into the desalination plant through an intake system. This method requires careful consideration of the location of the intake system to ensure that the seawater quality meets the required specifications, and to minimize the impact on marine life and the environment. Direct seawater intake systems can be designed as open or closed systems. Open systems allow seawater to pass through screens or filters before being pumped into the plant, while closed systems use a closed loop that circulates seawater through pipes or canals.

Boreholes for seawater collection involve drilling wells into the ground to access underground seawater sources. This method is commonly used in the Canary Islands due to the extensive network of protected natural spaces and species. Boreholes can be vertical or horizontal, depending on the characteristics of the site and the required water flow rate. The use of boreholes can be limited by the availability of suitable underground seawater sources, as well as by the potential for saltwater intrusion and other environmental impacts.

In addition to these methods, some desalination plants may also use hybrid systems that combine seawater intake and boreholes, or other alternative water sources such as treated wastewater or brackish water. The choice of abstraction method depends on various factors, including water quality requirements, environmental considerations, and cost-effectiveness.

The disposal of the brine generated during seawater desalination is indeed a crucial aspect that needs to be carefully planned and executed to minimize its impact on the marine environment. The different methods of brine disposal that we have listed have their own advantages and disadvantages, and the selection of a particular method depends on several factors such as the location of the plant, the local marine environment, and the discharge regulations of the relevant authorities.

Direct surface discharge is the simplest method, in which the brine is discharged over the surface of the sea. This method is suitable for plants located in deep waters, where there is adequate dilution of the brine. However, if the discharge is done in shallow waters, it can result in the accumulation of brine on the sea floor, leading to the formation of a hyper-saline layer, which can have severe environmental consequences.

On riprap discharge involves the construction of a riprap wall at the discharge point, which helps dissipate the energy of the discharged brine and reduces its impact on the surrounding environment. This method is suitable for plants located in rocky areas where the construction of an outfall pipe is not feasible. However, this method is less effective in achieving the required dilutions compared to other methods.

With an outfall or discharge pipe, the brine is discharged through a pipeline that extends a certain distance into the sea. This method allows for better dilution of the brine, and the discharge point can be located in deeper waters, minimizing its impact on the surrounding environment. However, the construction of an outfall pipe is expensive, and its maintenance can be challenging.

With diffusers, the brine is discharged through diffusers that are located at the end of the outfall pipe. The diffusers help disperse the brine into the surrounding water, leading to better dilution and reducing its impact on the marine environment. However, the efficiency of diffusers can be affected by several factors such as water depth, currents, and tides.

With ejectors, the brine is discharged through an ejector system that pumps the brine into the deeper layers of the sea. This method allows for better dilution of the brine, and the discharge point can be located further away from the shore. However, the construction and maintenance of ejector systems can be expensive, and their efficiency can be affected by several factors such as water depth, temperature, and salinity.

All these brine discharge techniques may require better dilution of the brine, which is why many desalination plants have to add in their designs pre-dilution systems for the concentrate with seawater before it is sent to the outfall. In this way, the brine is retained in a tank or raft, where it is diluted with water directly from the sea. This lowers the saline concentration of the brine and allows for greater dilution, reducing the impact on the receiving environment.

However, this technique requires a seawater pumping system for the dilution, which increases the energy consumption of the plant.

Discharging brine to a borehole achieves better dilution of the brine, since it is not discharged at a focused point, and it also avoids the need to modify the coast, as it does not require the installation of a brine discharge pipe on the coast.

The industrial process of desalinating water has emerged as a vital resource and a burgeoning economic activity. However, the discharge of concentrated salt water, also known as brine, into the ocean at specific coastal points during this process can have significant effects on the marine environment. This impact is considered the most significant consequence of this activity [22].

In summary, the selection of a particular method for brine disposal depends on several factors, and a careful evaluation of these factors is necessary to minimize the impact of brine discharge on the marine environment.

The studies carried out in recent years in this area of research are more focused on the biological and physical effects of brine discharge, the environmental impact of desalination processes, and the energy consumption and environmental impact assessment of desalination plants and brine disposal strategies [23-25]. However, the subject matter in this article involves the environmental impact of seawater intake, which is a new topic in the field.

VII. CONCLUSIONS

Desalination is a solution to the increasing demand for fresh water in coastal areas with large fresh water needs. Unlike surface or underground aquifers, desalination can generate a large volume of high-quality water. The main factors that affect desalination are the environment and energy consumption, which can lead to high costs for pumping water to higher altitudes. However, desalination remains a viable option to meet the water supply needs of populations and agriculture.

The most commonly used seawater extraction technique for desalination is direct seawater intake. However, it entails the following problems.

- Ecological impact: One of the main problems with direct seawater intake is its impact on the marine ecosystem. The intake of large amounts of seawater can disrupt the natural environment, harm aquatic life, and alter the water chemistry.
- Corrosion and fouling: Direct seawater intake systems are highly susceptible to corrosion and fouling due to the corrosive nature of seawater and the presence of marine organisms such as barnacles, mussels, and algae. This can lead to reduced efficiency, increased maintenance costs, and a shortened lifespan of the system.
- Intake clogging: Seawater intake systems are also prone to clogging due to the accumulation of sediment, sand, and debris in the intake pipes, which can reduce the flow rate and cause damage to the system.
- Operational hazards: Direct seawater intake systems are exposed to harsh marine conditions such as waves, currents, and storms, which can cause damage to the intake pipes, caissons, and other components. This can result in operational disruptions, safety hazards, and costly repairs.

- Regulatory compliance: Seawater intake systems are subject to various regulatory requirements related to environmental impact, water quality, and discharge standards. Compliance with these regulations can be challenging and costly, and failure to comply can result in fines and legal action.

The advantages of a seawater collecting well versus a direct seawater intake include:

- Reduced impact on marine life and the environment: Boreholes for seawater collection avoid the need for direct seawater intake from the ocean, which can have a significant impact on marine life and the environment. By accessing underground seawater sources, boreholes can help minimize this impact.
- Consistent water quality: Boreholes can provide a consistent source of seawater with a relatively stable water quality compared to open seawater intake systems, which can be affected by changes in weather, tides, and other environmental factors.
- Increased reliability: Boreholes can provide a reliable source of seawater, particularly in areas where direct seawater intake may be challenging due to environmental or other factors.
- Reduced maintenance costs: Boreholes require less maintenance compared to open seawater intake systems, which can be prone to fouling and other issues that require regular cleaning and maintenance.
- Avoidance of coastal modification: Boreholes for seawater collection do not require the installation of a brine discharge pipe on the coast, which can modify the coastal environment and impact marine life.
- Overall, the use of boreholes for seawater collection can help minimize the impact of desalination plants on the marine environment and provide a reliable and consistent source of seawater for the desalination process.
- As its only disadvantage, drilling wells to extract seawater can pose a challenge if the permeability of the soil is low. This can result in a limited flow rate, which may not be sufficient to meet the water demand of the desalination plant. To overcome this, multiple studies may be required to ensure an adequate supply of seawater.

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