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Improved seawater intake and pre-treatment system based on Neodren technology

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Abstract

Consistent high quality pre-treatment of the feed water is one of the most important prerequisites for long-term successful operation of seawater desalination plants. A first step to fulfill this requirement is the use of directed drilled horizontal drains below the sea bed, a technology that has been developed by drilling experts based on experiences with dredge-less pipeline installations starting 1996. With the use of these horizontal drains the raw and fine screening, as well as conventional filtration of seawater will not be necessary due to the fact, that the sand of the sea bed will act as a “natural” pre-filter, separating all kind of solids and particles down to the micron range from the seawater to be fed to the desalination plant. This system, introduced as Neodren, can be operated in sandy and karstic sea beds as ecological and economical alternative for conventional open seawater intake systems and has even advantages in comparison with beach well installations. This technology for seawater intake and pre-treatment can also be adapted successfully in areas with high contaminated seawater. It minimizes the environmental impact and is safe against the destroying forces of waves in the coast line. It is applicable for desalination plants for the production of drinking water from seawater on any scale between several 100 m^3/d to several 100,000 m^3/d. In combination with micro-bubble flotation and ultrafiltration the process minimizes drastically the need for chemicals that are necessary usually for the pre-treatment of seawater in order to reduce the scaling and fouling potential and to prevent biofouling before feeding it for example to blocking-sensitive membrane elements of a reverse osmosis plant. Reduction of the costs related with infrastructure, logistics and operation can be achieved.

Keywords: Seawater intake; Seawater pretreatment; Seawater desalination; Reverse osmosis

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1. Introduction

Often, conventional seawater pre-treatment processes can have difficulty meeting some of the parameters required for reverse osmosis (RO) feed water, particularly the silt density index (SDI). Traditional purification and filtration processes and the correlated dosing of conditioning chemicals must be continuously optimised to meet the day to day, and in some cases sometimes hour to hour, changes in the feed water to ensure that the necessary values are achieved.

Suspended solids and colloidal materials in the feed water are one of the biggest problems in reverse osmosis systems. Even though most systems have pre-treatment including 5 micron cartridge filters, these fine particles are responsible for fouling of reverse osmosis membranes in continuous long-time operation. In order to provide a stable, long-term performance of the membrane elements, a low SDI (less than 3) is desirable in the feed water.

In order to avoid biofouling in the filter system — usually multimedia filter and the mentioned cartridge filter as polishing device — and with this in the desalination unit itself, a continuous presence of free chlorine is necessary in most of the cases. But in order to protect the membranes themselves against oxidation the residual chlorine has to be eliminated before being fed to the membrane modules, mostly dosing sodium bisulfite. All this can be optimized with the Neodren technology [1].

2. Neodren technology based on directed drilled horizontal drains

The technology of directed drilled horizontal drains below the sea bed, entitled Neodren®, has been developed by Catalana de Perforacions based on experience gained during the realization of projects in the field of dredge-less pipeline installation starting 1996 [2]. It constitutes a significant progress in seawater intake systems, because installing horizontal drains in a permeable stratum in the marine subsoil, with a direct recharge from the sea, a seawater harness with no turbidity and with a constant flow is achieved. With the use of these horizontal drains the fine screening of seawater will not be necessary due to the fact that the sand of the sea bed will act as a "natural" pre-filter already (Fig. 1).

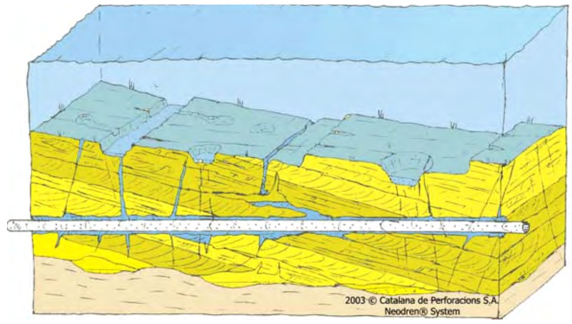

Fig. 1. Horizontal drain in the sea bed.

It is a system which allows getting the required flows thanks to a very efficient intake method, specially indicated for desalination plants, fish-farms, refrigeration systems and any application which requires seawater with excellent quality.

The filtrating pipes are installed in different boreholes, executed from the back of the coastline, by drilling the subsoil and going into the sea bed, entering, thus, the aquifer in the geological formation previously selected (Fig. 2). The porosity of the formation with its high permeability ensures the permanent recharge from the marine aquifer and the continuous extraction of large flows.

This very efficient harness system allows for the installation of pipe-drains in any geological formation, both rocky and granular type. The development of new drilling systems has led to technologies that are capable of stabilizing the drilled ground and cleaning of the surrounding areas, to get very efficient drains.

The horizontal directed drilling (HDD) allows steering the drill head to make very long drains (more than 600 m) inside the productive aquifer stratum. This technology enables to execute

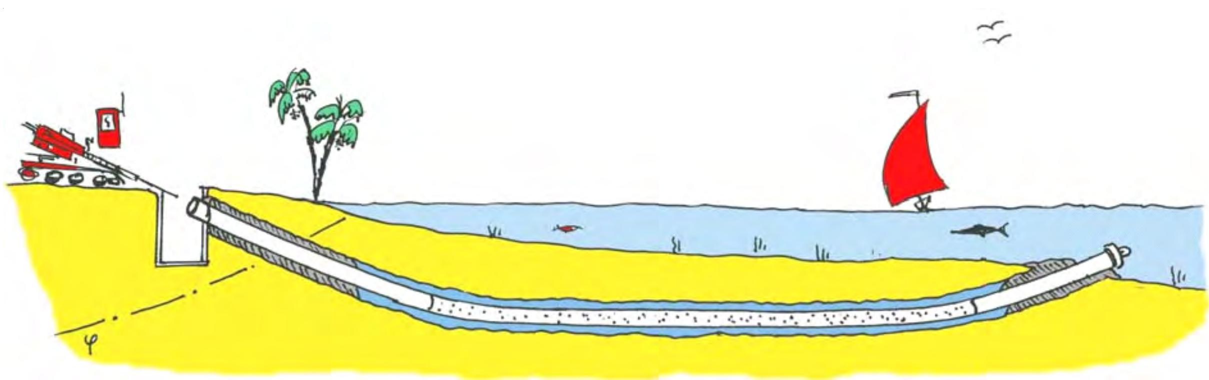

Fig. 2. Positioning of the horizontal drain.

drillings from the ground and come out in the sea, without affecting the intermediate path. To locate the drill head, magnetic guidance systems (MGS) are used, with a centimetric location precision, allowing the bore to be brought back, to obtain optimum results.

The pilot drilling is reamed by means of a pushing-reamer (Fig. 3), provided with a front guidance system to verify its right positioning in the pilot boring, enlarging it to the required diameter to install the filter.

When pushing, the detritus coming from the bore is carried out to the exit point, on land, preventing, therefore, an effect in the productive water extraction areas.

3. Design and capabilities

The first step in this kind of projects is a hydrogeological study from the site, which includes geological continental and marine cartography (Fig. 4), bathymetry and the realisation of vertical inspection drillings with continuous sample extraction [3].

Once the ground "anatomy" and the most favourable layout is completed, an experimental directed drilled horizontal drain is executed, in order to verify the work hypothesis and to make the pumping tests and the chemical analysis. When the viability is confirmed, the mesh or fan (Fig. 5, [4]) for the horizontal drains is projected and installed.

The system, expandable in capacity and with the possibility of reinforcing other existing intake systems, allows the achievement of large flows with the construction of drain batteries. From a location placed on the ground, so many drillings as needed are executed towards the sea, properly

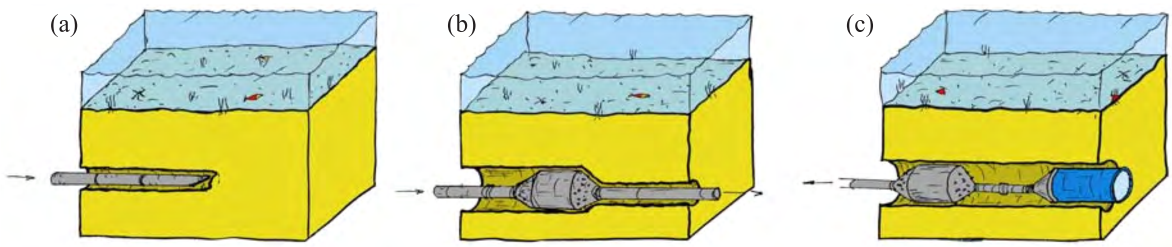

Fig. 3. Pilot drilling (a); enlargement with pushing-reamer (b); pipeline-installation (c).

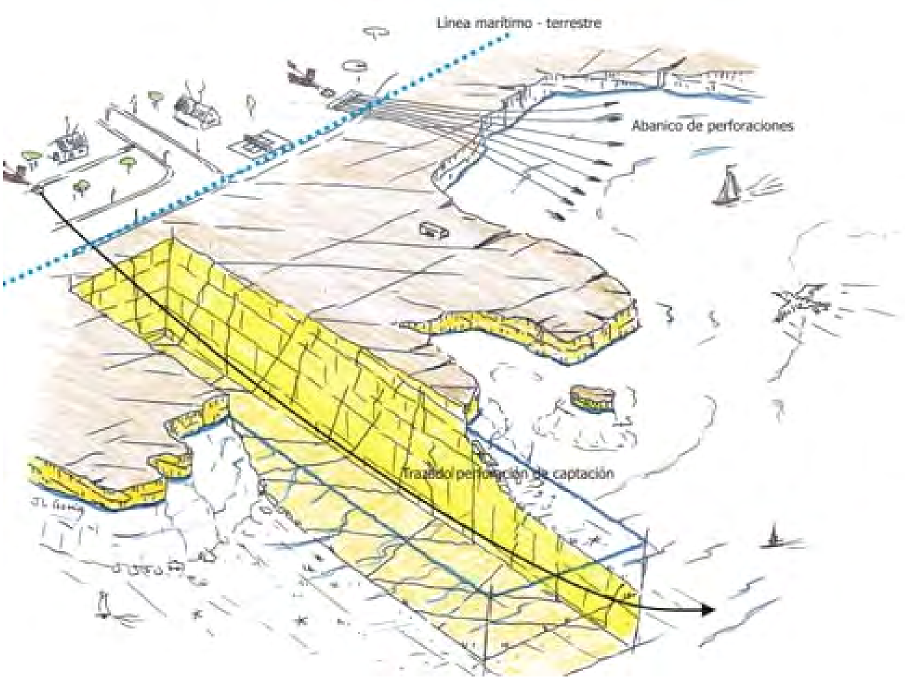

Fig. 4. Design for the drilling based on geological information.

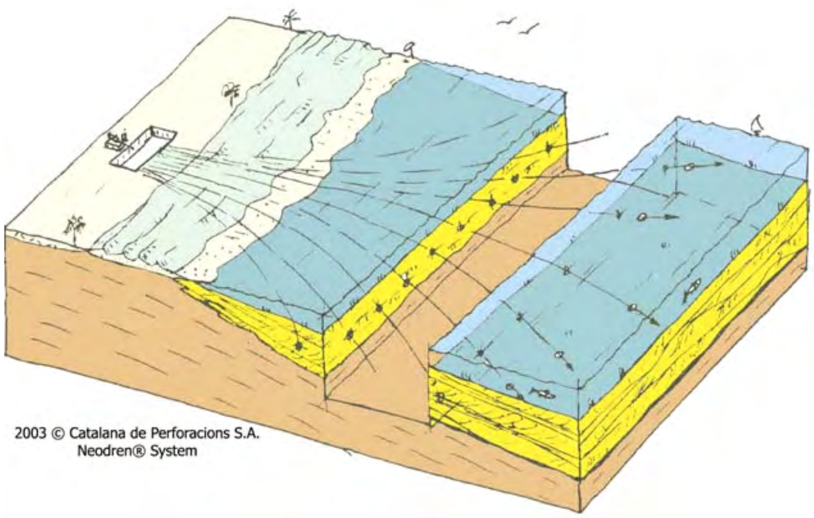

Fig. 5. Fan of horizontal drains.

separated between themselves, so as not to cause any affectation to the hydraulic stream towards the other drains.

Thus, it is possible harnessing large flows (for example in the range of 80,000–400,000 m³/d) from a small location in the continent, separated from the coastline and with the distance specified by the administrative and urban orders, and also the geological and logistic conditions.

One aspect in the Mediterranean area is the impact of seawater intake systems on the poseidonia prairies, that are highly protected by the environmental legislation. Drains installed in the subsoil below the seabed surface do not affect the ecosystem.

Examples for the installation of Neodren technology are:

1996	Fish-farm in Sant Pere Pescador	4,320 m³/d
2001	Fish-farm in Sant Pere Pescador (amplification)	8,640 m³/d
2003	Desalination plant in San Pedro del Pinatar	172,800 m³/d
2003	Fish-farm Cabo Cope	8,640 m³/d
2004	Desalination plant in Águilas	41,472 m³/d
2004	Desalination plant in Alicante, trial	500 m
2004	Cooling water for biomass plant in Albuixech	10,368 m³/d
2005	Investigation stage for the desalination plant in Barcelona, future feed flow	371,520 m³/d
2006	Desalination plant in Águilas, Comunidad de Regantes	25,920 m³/d

4. Neodren technology as basis for the NMU process

Further optimisation could be achieved if the filtrate produced with Neodren technology is treated with micro-bubble flotation and then with ultrafiltration, being this combination called NMU process [1]. This will consequently reduce additionally the efforts required in pre-treatment and lead to less investment and, by a dramatic reduction of the needed chemicals, to lower operating costs.

For the production of the micro-bubbles a device that allows for a very narrow distribution of the diameter of the micro-bubbles in order to improve the operating efficiency of the flotation should be used. Nozzle-based systems have proofed to be able to meet this requirement [5].

The last separation step of the NMU process is an ultrafiltration unit operated in dead-end-modus. The use of membranes in the pre-treatment of reverse osmosis — because of their reliable barrier-function — has been suggested in early times between other based on microfiltration [6]. Today it is an important application of ultrafiltration.

One important driving force for this development in seawater pre-treatment was the success of ultrafiltration in potable water applications [7,8]. The compact design of this kind of plant is shown in Fig. 6 [7,9].

Under discussion between experts is the pre-treatment of seawater with nanofiltration in front of evaporation plants in order to reduce the concentration of components dissolved in the seawater that could contribute to form scaling. The reduction of the concentration of these components will help to increase the efficiency, as higher recovery rates can be achieved. Therefore the protection of the spiral-wound elements equipped with nanofiltration membranes is considered to be another interesting application for ultrafiltration as part of the NMU process, that at least is based on Neodren technology.

5. Conclusions

Aspects concerning the Neodren technology for seawater intake and pre-treatment:

Effective:

- Obtaining water with the same quality as sea’s.
- No effect of dynamic action in the sea on the drain, due to its subterranean positioning.
- Elimination of turbidity from the seawater.
- Homogeneous temperature of the harnessed water.
- Constant recharge of the submarine aquifer.

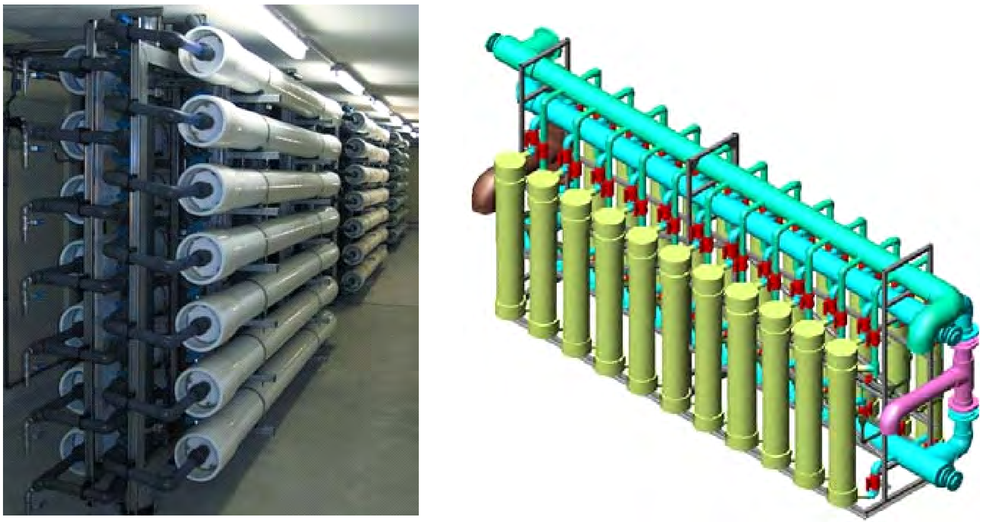

Fig. 6. Example for ultrafiltration units in horizontal and vertical design for dead-end operation, flow rates of 80 m³/h each rack.

Ecological:
- No changes in the coastline. No effect to the sea habitat.
- No dig excavation necessary in the seabed.
- No changes of the physical and biological sea environment.
- It does not affect the freshwater aquifers.
- Fixation of the sandy spots and submerged beaches in the seabed as side effect.

Quick:
- Superficial location of the drilling equipment, with no need of any ground disturbance.
- Positioning of the intake point in a reduced space
- Two reduced working areas, one on land, one offshore
- No blasting, breakwaters construction or seabed dredging.

Regarding desalination of seawater the use of the Neodren technology will help to
- simplify the pre-treatment in seawater desalination plants
- reduce the use of chemicals for seawater pretreatment
- reduce the frequency of chemical cleaning, that has an important influence to the lifetime of the membranes
- reduce the costs for membrane replacement
- reduce the costs associated with cleaning like handling, rinsing water, waste water discharge
- reduce the environmental impact correlated with the installation and operation of desalination plants with conventional seawater intake and pre-treatment
- improve the overall efficiency of desalination plants
- reduce the cost of ownership.

Summarizing, the Neodren technology, considered to be in accordance with the guidelines for a sustainable environmentally friendly development, can be addressed as an economical and ecological solution for seawater intake and pretreatment.

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