Optimization of a Filter Medium Suitable for Direct Irrigation with Seawater through a Water Table

Garcia Raurich, Josep[1*]; García Velasco, Alejandro[2]; Cusidó Lombera, Crisant[3]; Monagas Asensio, Pedro[4]; Arnal Madrid, Oriol[5]; Badrena Massó, Àlex[6]

[1,2,3,4]Centre de Recerca en Seguretat i Control Alimentari de la UPC (CRESCA)
[5]Fundación Aqua Maris
[6]Seawater Irrigation Systems, S.L.
*Corresponding Author

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Abstract**—** *The method that humanity has adopted to moisturize and thus bring to life the plants, imitating the model that was most visible, is rain. However, the great secret of irrigation lies in the land, in the water table and aquifers that treasure and manage water, sending away every drop of rain and spreading water through the underground basins of rivers, indirectly watering from the mountain to the Sea. The key is in the different circulation rates of groundwater because of the nature of the substrates. However, agriculture has adopted irrigation from above as we know it and has focused especially on drainage capacity. From this point of view, saline water is not beneficial for irrigated agriculture, but it may be the only source of irrigation water in large arid regions, especially in developing countries, where extreme freshwater scarcity and rapid population growth require more water.*

When it is raised the possibility of watering with seawater without desalination, always through capillary systems, it is essential to take into account the different soil strata, the distance to the water table, the composition of the seawater, the capacity soil chemical reactions to salts, etc. Modification of any of these parameters may produce salinization effects, moisture loss or desertification among others.

Keywords**— *Desertification, Desalination, Reuse, Marine Water Table.***

I. INTRODUCTION

Soil salinization is the process of accumulation in the soil of water-soluble salts. It can occur naturally, when it comes to low and flat soils, which are periodically flooded by rivers or streams; or if the groundwater level is shallow and the water rising by capillary contains dissolved salts (Chhabra, 1996).

When this process has an anthropogenic origin, it is usually associated with irrigation systems. It is called saline soil to a soil with excess soluble salts. Typically, the dominant salt is sodium chloride (NaCl). One consequence of soil salinization is the loss of fertility, which harms or makes agricultural cultivation impossible. Usually, the process is slowed or reversed by expensive washing of the soil to leach the salts or, alternatively, to grow plants that better tolerate salinity (Hoorn & Alphen, 2006).

On the other hand, it is known that the Inca culture developed a technology based on modifying the surface of the soil to facilitate the movement and storage of water. The main feature of this system is the construction of a network of embankments and channels, currently in use, as shown in Figure 1.

The water channels serve two very important functions, the first is to provide the water necessary for the growth of plants, since the proximity to water allows the area to remain moist and the plants can absorb the nutrients they need. The second function is to achieve a temperature more suitable for plants than the environment. The body of water allows to absorb excess cold in the nights and winter periods, preventing frosts from affecting the plants. Likewise the water absorbs the midday heat and radiates it at night where it is necessary to balance the cold of the night (Carolina Sparavigna, 2010).

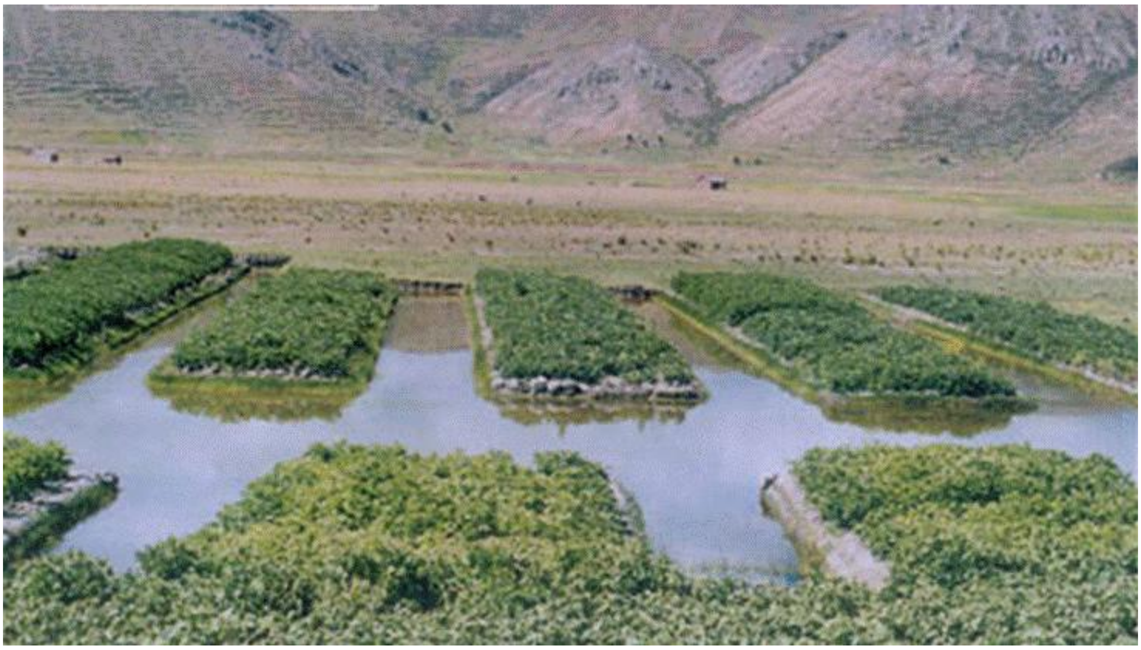

FIGURE 1: Set of embankments known as waru in the highlands of Peru.

Terraced agriculture is a phenomenon developed since time immemorial and distributed throughout the globe. In Asia: Sumatra, Philippines, Yemen, Nepal, China, Turkey, Pakistan and elsewhere. In Africa: Ethiopia, Sudan, Uganda, Tunisia, Algiers and others. In Europe: Spain, Portugal, Italy, Romania, France, Switzerland and other places. In America: from the southern United States to northern Argentina (Donkin, 1979).

Almost two thirds of the water used by man goes to agriculture. In Asia, the proportion increases to four fifths. Agriculture also impacts the basis of its own future through land degradation, salinization, excess water extraction and a reduction in agricultural genetic diversity. To date, issues related to water resources have not been adequately addressed in climate change analyzes or in climate policy-making (Bates, et al., 2008).

Globally, a water volume of more than 1,000 m3 per inhabitant per year is considered more than necessary for domestic, industrial and agricultural uses. As a result, a basin is estimated to suffer from water stress when its water availability per capita is less than 1,000 m3 /year (based on the historical average runoff) or when the ratio between water extraction and the annual historical average of runoff is greater than 0.4. There are such basins in North Africa, the Mediterranean region, the Middle East and the Middle East, South Asia, Northern China, the United States of America, Mexico, northeastern Brazil, and the western coast of South America. The population living in these basins amounts to an estimated total of between 1.4 billion and 2.1 billion people (V.R.Smarty et al., 2000; Alcamo et al., 2003a, b; Oki et al., 2003; Arnell, 2004).

Currently, agriculture is one of the main contributors of greenhouse gases, with 13.5% of the world's emissions. At the same time, climate change increases the risks and uncertainty of farmers, by warming and consequent aridity, by changes in rainfall regimes and by the increasing incidence of extreme weather events (FAO & Earthscan, 2011).

Irrigation accounts for about 70% of the water extracted worldwide and accounts for approximately 40% of agricultural production (Fischer et al., 2006). In fact, irrigated lands, which account for only 18% of the world's agricultural land, produce 1 billion tonnes of cereals per year, accounting for about half of the total world supply; this is because irrigated crops produce, on average, between 2 and 3 times more than rain-dependent crops (Alexandratos, N., 2005).

Overall, global warming appears likely to benefit agriculture in developed countries in temperate areas and have adverse effects on the production of many developing countries in tropical and subtropical areas. Climate change could therefore increase developing countries' dependence on imports and accentuate the differences between north and south in food security (Canadell et al.,2007).

Water management aims to improve the quantity and quality of available water. The ways to achieve this are: regulate the use of surface and groundwater, develop alternative sources of water, rationalize their consumption, control the supply of pollutants and recover initial conditions through purification processes. The objective of good water conditions should be pursued in each watershed, so that measures relating to surface water and groundwater belonging to the same ecological, hydrological and hydrogeological system are coordinated (Directive 2000/60/EC). From this perspective, the reuse of purified waters is an essential element of the natural water cycle and is, in fact, seen as a measure to solve the problems of water scarcity.

Given the high pollution rates of rivers, reservoirs and groundwater, an important option is presented: the desalination of seawater to obtain consumable water (Lechuga et al., 2007). Their demand has increased considerably in recent years. This is mainly due to the serious water resource shortage suffered in various parts of the planet.

In recent years, the idea that water management should be understood as an instrument in the service of an explicit territorial policy has been reinforced and that it will also be supported by the growing demand for integration between water management and sectoral policies (Moral 2009). From this perspective, this study proposes the direct use of seawater, without going through a process of prior desalination, as a fluid to be used in the irrigation of various types of cultivation.

II. MATERIAL AND METHOD

All the experiences that relate in this study have in common that seawater was circulated underground. In this way, by capillary, the seawater was dispersed through the corresponding solid substrate.

2.1 Material in contact with seawater

Preliminary studies (García et al., 2019) showed that the direct use of seawater as an irrigation fluid, as long as it is administered phreatically, is viable. However, this necessary condition is not enough. It is necessary to have a substrate as a filter with certain characteristics (composition and granulometry) that allow reducing the saline content and keeping the humidity at a sufficient height so that the roots of the cultivated vegetables can absorb enough water and nutrients without reaching to toxicity limits.

Based on the climatic classification, proposed by Kóppen and modified by Geiger (Kottek et al., 2006), it was estimated that a first use of seawater as an irrigation fluid would be appropriate in semi-arid climates, both warm (BSh) with an average temperature annual above 18°C and an average annual rainfall between 300 and 700 mm (tropical and subtropical semi-deserts) as cold (BSk) with an average annual temperature below 18°C and an average annual rainfall between 250 to 500 mm (temperate and cold semi-deserts). Consequently, as substrates materials were chosen that I can find in arid areas such as beach sand and fine grain aggregate, in this case from quarries and subjected to a crushing and sorting process. The particle size of both substrates was between 0.06 and 4 mm.

The initial objective was to determine the height that, by capillary, seawater would reach in the presence of these substrates. For this purpose, some specimens made of plastic tubes (PVC), 60 cm high and 18 cm in diameter were prepared. At the lower end, in contact with seawater, a net was incorporated thick enough to maintain the substrate. Once carefully refilled to prevent the formation of air chambers, these tubes were inserted in trays 2 m long, 1 m wide and 7 cm high through which seawater circulated and that allowed to maintain a constant water height of 3 cm. It worked on open circuit, so that seawater was continuously renewed.

Two working groups were established. The first group of tubes was filled only with the fine grain arid, while the filling of the second group consisted of a 10 cm high layer of beach sand at the lower end and the rest of the tube was filled with the fine grain arid, as shown in Figure 2.

In order to determine the evaporation rate of water on the surface of each tube, both groups were subdivided into three subgroups: a) tubes without surface protection, b) tubes with full surface protection, c) tubes with partial surface protection, as shown in Figure 3, and an experience was scheduled to subject all the tubes to a 24-hour seawater flow over a variable time period of 1, 2, 4, and 8 weeks, as shown in the diagram in Figure 4.

(a) (b)

FIGURE 2: Appearance of the two types of tube used a) without filter b) with beach sand filter.

(a) (b) (c)

FIGURE 3: a) tube without surface protection b) tube with partial surface protection c) tube with full surface protection.

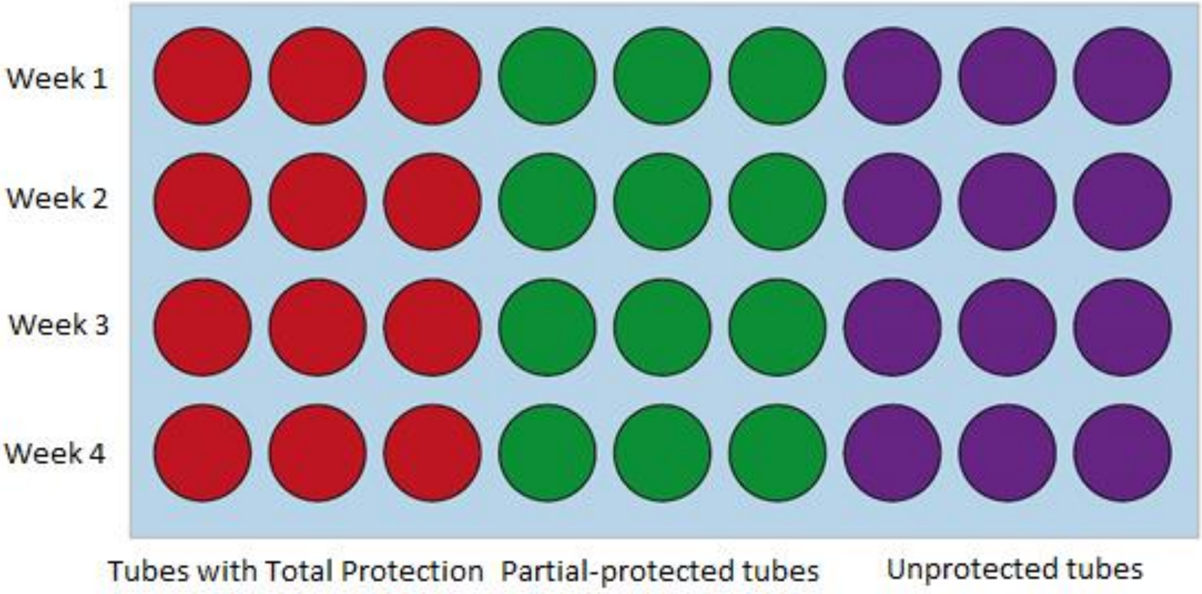

FIGURE 4: Temporal and spatial distribution of all tubes (with filter and without filter)

2.2 Sampling and determined parameters

The height of the tubes that did not contain a beach sand filter was divided into 5 sections, while the tubes that contained this type of filter their height was divided into 6 sections, so that one of the samples corresponded to the sand filter of beach and the rest to the fine grain aggregate used in the experience.

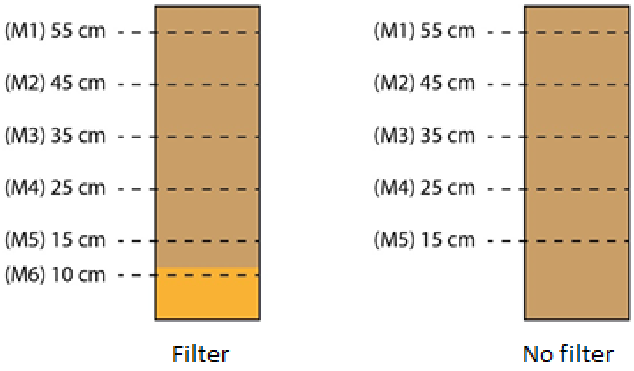

FIGURE 5: Dimensions where samples were taken in filter and no filter tubes

Once the samples had been collected and closed in airtight containers, moisture, conductivity and pH were determined.

Experimentally, the first parameter determined was humidity at the different dimensions set (see Table 1). To do this, different samples, of known weight, were subjected to 110oC inside a laboratory stove over a period of 48 hours. Then, they were introduced into a desiccator until room temperature was reached and it was weighed. The weight difference determined the moisture value of each sample. The determination of the weights was carried out with a SCALTEC SBA 52 precision balance and heat treatment with a Nahita 631/4 laboratory stove.

TABLE 1
EVOLUTION OF MOISTURE IN THE DIFFERENT SETS OF TUBES.

Humidity (%)		With filter (B1)				Without filter (B2)			
		Week 1	Week 2	Week 4	Week 8	Week 1	Week 2	Week 4	Week 8
With lid (T)	M1	4,56±1,44	6,35±1,52	7,80±0,05	6,55±0,22	2,87±0,36	6,48±0,34	7,54±0,23	6,57±0,34
	M2	5,18±1,57	5,78±0,61	6,84±0,41	7,33±0,29	3,24±0,05	6,76±0,79	7,16±0,09	6,83±0,56
	M3	6,14±2,02	6,91±0,26	7,96±0,66	7,88±0,34	3,56±0,21	7,09±0,29	8,73±1,11	7,35±0,47
	M4	7,45±2,05	8,88±0,34	9,18±0,71	8,99±0,86	9,11±0,43	8,63±0,43	9,22±0,75	8,60±0,36
	M5	11,93±0,46	9,76±0,73	10,56±0,65	10,99±1,88	11,34±0,47	11,08±0,91	11,57±1,04	10,31±0,57
	M6	7,76±0,20	10,11±1,14	8,00±0,09	5,63±1,55				
With hole (A)	M1	2,56±0,09	2,29±0,76	6,64±0,08	6,31±0,39	4,21±1,61	5,46±1,11	7,43±2,34	6,18±0,40
	M2	4,04±0,79	4,89±1,17	6,65±0,87	6,27±0,23	5,24±1,52	6,38±0,84	6,68±1,12	7,00±0,47
	M3	5,18±1,44	6,20±0,96	7,57±0,86	7,02±0,10	6,51±1,53	7,16±0,68	7,47±1,08	7,77±0,60
	M4	6,91±1,37	7,76±1,31	9,97±1,09	8,37±0,67	9,18±0,09	9,09±0,47	8,44±0,06	9,32±0,65
	M5	8,61±2,24	8,94±1,67	10,45±0,50	9,73±0,30	12,67±0,44	10,65±0,25	10,35±2,71	10,58±0,23
	M6	7,17±0,20	12,19±1,41	9,18±1,02	8,32±0,23				
Without lid (N)	M1	1,26±0,08	0,91±0,04	4,38±2,50	7,31±0,90	1,06±0,03	5,52±0,22	6,36±0,22	8,13±0,01
	M2	2,97±0,03	2,61±0,32	6,09±1,99	6,97±1,07	2,93±0,10	6,44±0,27	7,27±0,06	10,24±1,41
	M3	3,18±0,06	3,59±0,23	7,27±1,69	7,15±1,61	4,07±0,54	8,08±0,15	8,06±0,32	10,01±0,21
	M4	3,43±0,10	5,10±0,33	9,36±2,63	8,16±1,23	9,08±0,21	8,62±0,05	8,85±0,30	10,52±0,63
	M5	3,53±0,14	5,31±0,48	8,23±2,60	9,21±0,88	12,43±0,75	9,80±0,13	11,10±0,32	11,93±0,49
	M6	5,07±0,28	8,66±1,76	8,19±1,48	6,78±0,31				

In unfiltered tubes, a clear trend was observed: the decrease in humidity as they were taken show further away from dimension 0, especially in those tubes that were not protected. In which they were protected, in whole or in part, the values at the upper end of the tube were influenced by the effect of evaporated water condensation on the protective surface.

Once the humidity present in the samples was determined, the content of salts that had been retained in the substrate as a result of direct contact with seawater was determined.

It was preceded as follows: 10 grams of each dry sample from the previous test were inserted into a screw cap container. Then 200 mL were introduced distilled water. To achieve a total dissolution of the salts contained in the sample, a magnetic stirrer (fly) was inserted into the beaker and kept in agitation at 800 rpm for 10 minutes. The contents of the container were left at rest for 24 hours in an airtight manner, decanted and filtered.

The volume of filtered liquid was sufficient to determine conductivity and pH. The conductivity was determined at a temperature of 25°C using a Jeulin JLC20 conductivity meter and the pH using a Thermo Scientic Orion 2 Star pHmeter.

It was found that the pH value remained virtually constant in all experiences, with a value of approximately 8 units. On the contrary, the values of humidity and conductivity evolved differently, observing a progressive decrease of both parameters, as they are determined in samples increasingly far from the base of the tubes, where seawater was constantly circulated with a conductivity value of 55 mS/cm.

As far as conductivity is concerned, both in the experiences carried out in fully covered tubes and in partially covered tubes, the value of this parameter, at eight weeks was maintained, at surface level, at values below 5 mS/cm. Only in those experiences made with tubes without any protection were achieved values of 15 mS/cm, in the case of using the beach sand filter and 19 mS/cm in the absence of this filter.

TABLE 2
EVOLUTION OF CONDUCTIVITY IN THE DIFFERENT SETS OF TUBES.

Conductivity (mS/cm)		With filter (B1)				Without filter (B2)			
		Week 1	Week 2	Week 4	Week 8	Week 1	Week 2	Week 4	Week 8
With lid (T)	M1	2,91±0,57	2,84±0,77	3,51±0,96	3,15±0,25	4,08±0,33	3,68±0,76	3,39±0,22	5,25±0,47
	M2	3,57±0,50	3,69±0,47	3,98±0,43	4,19±0,29	2,58±0,84	4,15±0,07	3,76±0,50	4,39±0,25
	M3	5,71±2,55	5,19±0,26	7,26±1,16	7,23±0,51	2,92±0,95	6,02±1,41	6,42±0,10	7,79±0,39
	M4	7,22±3,45	7,96±0,53	10,28±0,85	8,57±1,53	5,68±1,86	10,36±2,28	9,29±0,50	12,57±0,84
	M5	8,97±2,42	10,49±1,34	11,34±0,67	12,48±3,95	13,60±3,33	12,50±3,06	11,50±0,25	14,89±2,32
	M6	6,71±0,46	8,80±2,06	8,80±0,96	8,39±3,22				
With hole (A)	M1	3,48±0,22	3,65±0,53	3,67±0,44	4,78±0,16	2,18±0,25	3,29±0,17	4,83±1,06	5,27±1,51
	M2	3,81±0,49	3,57±0,67	4,18±0,24	5,50±0,78	2,97±0,84	4,01±0,36	4,29±1,23	4,84±0,90
	M3	3,34±0,78	4,89±0,68	6,29±1,69	7,59±0,64	4,39±0,54	5,48±1,17	6,88±1,99	7,31±1,24
	M4	6,67±2,82	8,77±1,62	9,33±0,93	9,81±1,23	6,15±1,01	9,43±0,74	10,14±1,79	10,52±3,21
	M5	11,85±4,21	9,83±0,59	9,90±0,15	10,95±0,76	11,87±1,88	11,02±0,15	11,78±2,08	15,42±2,32
	M6	9,27±1,42	10,90±2,83	7,94±1,68	8,36±0,29				
Without lid (N)	M1	2,93±0,30	3,03±0,66	7,44±2,90	15,65±1,65	4,23±0,61	3,56±0,75	6,53±0,97	18,65±5,16
	M2	3,08±0,78	2,82±0,82	6,33±2,13	7,23±2,55	4,31±0,16	4,17±0,04	5,98±0,22	8,02±1,80
	M3	2,98±0,98	2,83±1,18	7,08±2,56	8,14±1,06	3,47±0,11	6,68±0,06	7,13±0,43	11,37±1,43
	M4	2,71±0,88	5,17±0,68	12,50±4,07	9,30±1,20	5,24±1,08	9,08±0,36	8,40±0,42	12,73±1,66
	M5	7,31±2,84	5,75±1,52	8,51±3,14	9,76±0,64	12,61±2,41	10,84±0,26	10,29±0,37	27,11±0,52
	M6	7,52±1,55	6,92±2,08	7,96±0,92	9,05±0,92				

2.3 Optimizing the filter media

In view of a reduction in the order of 90% achieved for surface values of conductivity with a height of 60 cm, it was proposed to optimize the behavior of the filter medium.

Two objectives were set:

a) Minimize conductivity and maximize moisture.
b) The filter media had to be recoverable on site, since in a large-scale capillary irrigation system it is unfeasible to have to replace the materials used often.

The filter media component used in this study was beach sand screened and separated according to particle size. The sand composition used based on the particle size is shown in the following table.

TABLE 3
COMPOSITION OF THE SAND ACCORDING TO THE PARTICLE SIZE

Diameter (mm)	Composition (%)
d > 1,5	6,04
1,5 > d > 1	34,45
1 > d > 0,5	58,55
0,5 > d > 0,3	0,35
0,3 > d	0,61
TOTAL	100,00

Separately used 1 mm top granulometry sand, with a granulometry of less than 1 mm and unscrat sand. In this way, the potential for ascension by capillary of seawater could be compared in the same medium with variable granulometry.

In a first experience a PVC tube of 57 mm diameter, filled with beach sand of granulometry less than 1 mm to a height of 30 cm, was introduced in a container containing a layer of seawater 3 cm thick and that was renewed each day to prevent the formation of brine due to evaporation.

At four weeks, the electrical conductivity was determined at different levels, taking as a reference the interface between beach sand and seawater (0 cm). The dimensions chosen were: 0; 2,5; 5; 7,5; 15 and 30 cm. It was found that seawater had not exceeded the 15 cm height. Conductivity values are shown in Table 4.

TABLE 4
EXPERIMENTAL VALUES OF CONDUCTIVITY AND ITS EQUIVALENCE IN NaCl (g/L)

Dimension (cm)	CE (mS/cm)	[NaCl] g/L
0	1,017 ± 0,004	4,60
2,5	0,785 ± 0,002	3,48
5	0,558 ± 0,006	2,39
7,5	0,224 ± 0,001	0,78
15	0,123 ± 0,001	0,30
30	0,104 ± 0,001	0,21

In view of this result, a waterproofed canal with drainage system was built to control the maximum seawater height of 80 cm long, 34.7 cm wide and 20 cm high. A pump was used for water circulation with a flow rate of 4 L/min and worked in open circuit, i.e. with seawater renewal. Periodic renewal of the canal water was scheduled every 12 hours, to maintain an artificial water table 3 cm thick by renewing the water, avoiding the generation of brines by progressive accumulation of salts.

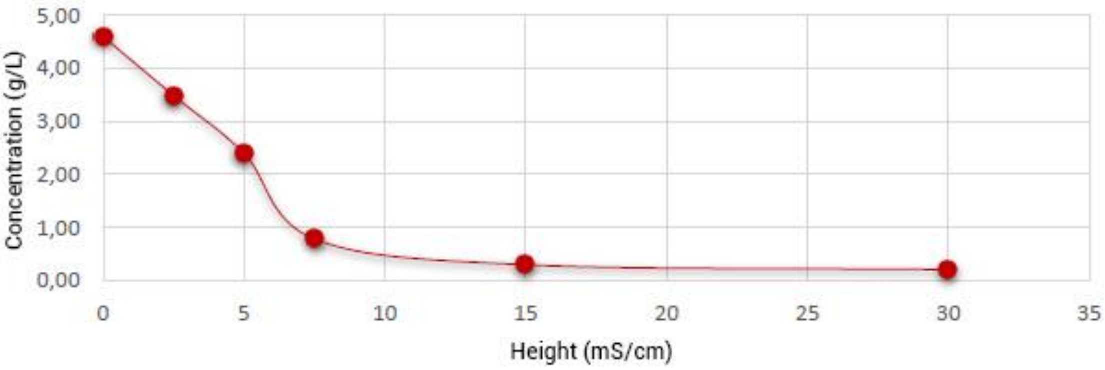

FIGURE 6: Graphical representation of electrical conductivity relative to the sampled dimension at four weeks

Thirty-six tubes 57 mm in diameter were prepared and available as shown in Figure 7. The different tubes were differentiated as follows: "P" corresponds to particles less than 1 mm; "G" with particles greater than 1 mm and "M" with unscreld beach sand.

P.4.1	P.4.2	P.4.3	G.4.1	G.4.2	G.4.3	M.4.1	M.4.2	M.4.3
P.3.1	P.3.2	P.3.3	G.3.1	G.3.2	G.3.3	M.3.1	M.3.2	M.3.3
P.2.1	P.2.2	P.2.3	G.2.1	G.2.2	G.2.3	M.2.1	M.2.2	M.2.3
P.1.1	P.1.2	P.1.3	G.1.1	G.1.2	G.1.3	M.1.1	M.1.2	M.1.3

FIGURE 7: Arrangement of PCV pipes in the seawater channel

Three tubes were allocated for each type of composition and sampling time, and three repetitions of each test can be made. Samples were taken at 4 and 8 weeks of different dimensions.

The pipes were divided into two groups: those that were not subjected to freshwater irrigation (rows 1 and 3) and those that were subjected to irrigation with 2 L of distilled water from its top (rows 2 and 4) at three weeks after the experiment began. Figure 8 shows the mean values of electrical conductivity within four weeks of starting the experiment.

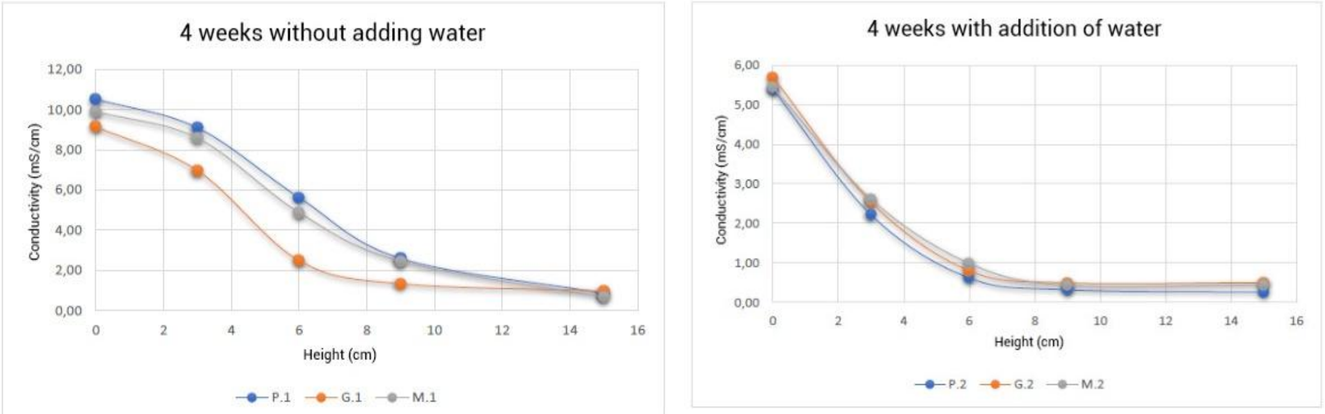

FIGURE 8. Evolution of conductivity at four weeks a) samples without irrigation b) samples with irrigation.

The EC value at level 0 in samples that were not washed with distilled water was significantly higher than the EC value at level 0 in samples subjected to distilled water irrigation, a fact that confirmed the reversibility of the filter. Leaching to reduce salt concentration was found to be a highly effective method. It is achieved by accumulating fresh water on the surface of the soil and allowing it to infiltrate. Leaching is effective when salt drainage water is discharged through underground drains that carry leached salts, as was the case.

The behavior observed in the samples analyzed after a four-week period was corroborated by the one observed at eight weeks (Figure 9).

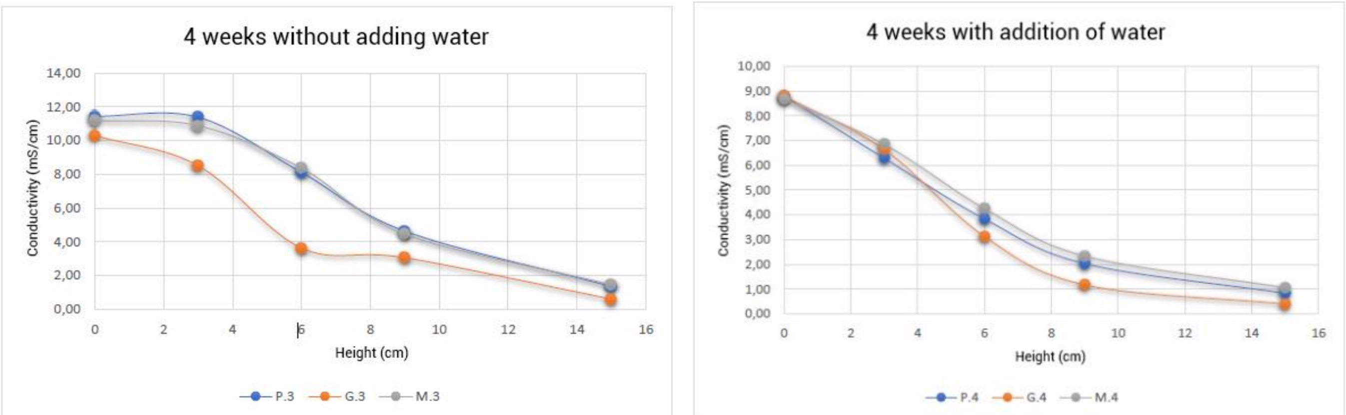

FIGURE 9: Evolution of conductivity at eight weeks a) samples without irrigation b) samples with irrigation.

From all the experiences, the different behaviour of the unscreened samples is inferred in experiences without surface irrigation with distilled water, at heights increasingly far from the reference point (0 cm), with lower CE values.

Based on the classification of soil types according to electrical conductivity (Abrol et al., 1988), unscrel dying provided a non-salt floor 9 cm from the water table (dimension 0) within four weeks of the experiment. By eight weeks, the EC had increased and slightly saline ground was available (see Table 5).

TABLE 5
CLASSIFICATION OF SOILS ACCORDING TO ELECTRICAL CONDUCTIVITY

Soil type	CE (dS/m)	Effect on crops
Non-salt	0 - 2	Insignificant salinity effects
Slightly saline	2- 4	Yields of sensitive crops may be affected
Moderately saline	4 - 8	Yields of many crops are restricted
Strongly salted	8 – 16	Only tolerant crops yield satisfactorily
Very strongly salty	> 16	Only a few very tolerant crops yield satisfactorily

Moreover, when EC values were considered in freshwater leaching experiences, the results corresponded to non-salt terrain on both occasions.

III. DISCUSSION

The capillary height that reaches the water in the soil is determined by considering a mass of soil as a large network of capillary tubes formed by the voids existing in its mass. Unlike capillary tubes, soil vacuums have variable width and communicate with each other in a latain. If this latat is communicated below with the water, its bottom becomes completely saturated. Higher the water only occupies the small voids and the larger ones are left with air. In a thin soil, the saturation level is above the water table by capillary ascension. The height reached is bounded by the weight of the water in the canals, when equalising the surface tension force (Atkinson, 1978).

Salinization is one of the major threats to agriculture worldwide, and it is a growing problem. In general, crops produce lower yields at higher salinity levels, and in the worst case, farmers have to leave their fields and clean up new land that increases pressure on natural ecosystems and associated biodiversity. In addition, salinity is expected to increase further, according to current predictions of climate change. Therefore, with a growing global population and climate change on a global scale, salinity is a problem that will only grow in importance and urgently requires a solution (Qadir et al., 2014).

A practical salinity index is electrical conductivity (EC), expressed in deciSiemen units per meter (dS/m), equivalent to mS/cm. Electrical conductivity values are always expressed at a standard temperature of 25oC to allow comparison of readings taken under different climatic conditions. Water with a CE less than 0.7 dS/m is considered non-salt or sweet water, while 2 dS/m is considered the maximum value for irrigation water (Rhoades et al, 1992).

High levels of salinity in the soil affect plants in several ways. First, it decreases the osmotic potential of soil pore water. This makes water absorption more difficult for plants as the plant has to decrease the osmotic potential of the roots to levels below the osmotic potential of soil moisture.

Second, NaCl molecules that are incorporated into the plant with water can cause physiological damage. Na+ ions, especially, can quickly reach toxic levels within the plant. Finally, due to the high concentrations of Na+ in soil pore water, competition occurs with K+ potassium ions, essential for plant growth, and plants may have difficulty absorbing enough K+ (Vos et al, 2016).Arid lands are among the most fragile ecosystems in the world, and their fragility is accentuated by periodic droughts and the increasing overexploitation of meager resources. Arid and semi-arid lands cover about a third of the area of emerging land, and there is a population of approximately one billion people who are mostly among the poorest in the world (Belaz, 2003).

The United Nations Conference on Environment and Development (UNCMAD, 1992) defined the concept of desertification as "the degradation of lands in dry, semi-arid and sub-humid areas as a result of various factors, including climatic variations and human activities". Desertification does not consist of the advance of existing deserts, but is a consequence of the effect of localized land degradation, and occurs rapidly after deforestation and soil depletion.

Desertification is a global problem that directly affects 250 million people; desertification particularly affects Africa, as three-quarters of the continent is drylands and deserts. However, more than 30 percent of the lands of the United States of America are also affected by desertification. A quarter of the surface of Latin America and the Caribbean are deserts and drylands. In Spain, 20 percent of the land is at risk of becoming desert. In China, since the 1950s, sand displacement and degradation have affected nearly 700,000 hectares of cultivated land, 2.35 million hectares of grasslands and 6.4 million hectares of forest, clear mountain and shrubland.Worldwide, about 70 percent of the 5.2 billion hectares of dry land used for agricultural activities are degraded and endangered desertification (FAO, 2007).

Currently, the main limitation of irrigated agriculture is the availability of water, both in terms of quality and quantity (García-Vila & Fereres, 2012). This scarcity can be due to several causes: aridity, drought, desertification or water stress (Pereira, et al., 2002).

With the increasing competition for non-renewable water resources around the world and the growing demand for agricultural products, the need to improve the efficiency and productivity of water use for crop production has never before been so pressing to ensure future food security and to address the uncertainties associated with climate change (Steduto, et al.2012).

The incorporation of desalinated seawater in irrigated areas is another alternative that has been on the rise in recent decades. Globally, major agricultural irrigation experiences with desalinated water show that, in many countries with arid or semi-arid climate, and which also have highly technical agriculture, brackish water desalination represents an additional source of (Anzecc & Armcanz, 2000). There are many countries (Israel, Spain, Malta, Australia, southern US states, Middle Eastern countries, North African countries, etc.) that have made use of different desalination technologies to ensure the domestic supply of water to their populations (Duranceau et al., 2011).

The Reverse Osmosis (OI) technique has become the reference technology for seawater desalination, as it has reduced energy consumption and production costs compared to other large-scale applicable technologies (Shaffer et 2012). Despite the competitive advantages of the (OI) over other desalination techniques, it still involves very high-energy consumption (Melgarejo & Montano, 2011).

Desalinated seawater is presented as a guaranteed resource of water, as it is part of an inexhaustible source. However, it presents a number of special features that may limit its direct use for agricultural irrigation, which must be considered and analyzed appropriately to be corrected if necessary with appropriate after treatments (Martinez-Beltran, 2006).

Desalinated water, especially if it has not undergone remineralization processes (ROSW), is characterized by low salinity and a very different salt composition than natural waters. The concentration of Na^+ and Cl^- is usually high in relation to natural waters, while the presence of Ca^{2+}, $Mg^{2+}$and SO_4^{2-} is minimal (Yermiyahu et al., 2007).

If only irrigation water quality is taken into account, regardless of the other factors, you can ensure that, beyond thresholds characteristic of each crop or variety, as the electrical conductivity of the water (EC) increases the crop yields. However, there is a history that seawater has been used without desalination as irrigation water for crops (Iyengar, et.al, 1968).

Given the forecasts accepted by the main international agencies, the use of filter media that allows the development of crops directly with seawater (without desalination) will provide a number of advantages that will allow alleviating the short-, medium- and long-term needs. These advantages include:

- The release of fresh water for irrigation (redistribution for other uses)
- The use of arid areas for cultivation
- The provision of an unlimited resource at the global level
- The promotion of sustainable agriculture with job creation
- The contribution to satisfying the nutritional demand of a significant part of the world's population, which is constantly growing, in the near future.

The use of affordable materials will allow a wide development of this proposed irrigation model.

IV. CONCLUSIONS AND PERSPECTIVE OF THE FUTURE

The results obtained experimentally allow to state that the direct use of seawater as irrigation fluid, provided that it is administered in a phreatic way is feasible. However, this necessary condition is not sufficient. A filter substrate with certain characteristics (composition and granulometry) that reduce saline content and maintain moisture at a sufficient height is required so that the roots of cultivated vegetables can be reduced absorb enough water and nutrients without reaching toxicity limits.

In this study, it has been shown that the beach sand meets these requirements and that it can be regenerated by leaching with fresh water. An economic and abundant filter environment is therefore available. Conductivity levels need to be controlled. In this sense, in addition to the method of regeneration of the filter media, it is advisable to look for alternatives that allow controlling this balance. A very promising prospect is the incorporation of bioadsorbents, mainly from waste from the agri-food industry.

In addition, it is worth taking into bear in mind the climatic influence (rain, wind, temperature...) as long as this experience is not carried out inside a greenhouse where environmental conditions can be regulated. This is especially important for areas with a very low or no rainfall regime where the phenomenon of evaporation at surface level can cause a concentration of salts at undesired levels.

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