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Desalination of Thermal Water from Ixtapan De La Sal, Mex. by Means of Chemical Reactions, Ultrasound and Flotation Cell

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Abstract: It is an excellent process because, the sodium chloride was converted into AgCl and calcium, sodium sulfate. The silver can be recovery from AgCl and from the final solution. Only it is necessary to design new tests in order to improve the time duration process and chemical reactive dose. Because for the equipment used, the process can be scaled to a largest seawater desalination. The bactericidal effect of the process and ultrasound is very important because the final water could be drinkable without harmful bacteria. Only spores and fungus remained 0.35% using ultrasound. The same process could be good for the seawater desalination because the chemical reactions are the same.

Key words: Thermal geyser, hot-baths, molecular dissociation, ultrasonic, flotation cell excitation

INTRODUCTION

The population increases and residents consume more fresh water. In order to solve this problem, it is necessary to find a gentle and inexpensive process for water desalination.

China has a large and growing demand, Japan has a large demand and also the Middle East. It is a worldwide problem (Klausner, 2004).

Actually, the water desalination problem is the high costs. On this research, we are using the interesting quality of the ultrasonic waves because they can be developed into several harmonics that can dissociate the water molecule (Suslick, 1988; José F. Ábrego López, 2006).

The advantage of this process, is the recovery of silver from the AgCl byproduct. It might be an economical process.

On this new process, using the waves additive phenomenon, it was possible to accelerate the chemical reactions and to dissociate the stiffness molecule of NaCl.

Several countries, in order to find an economical process, are using Inverse Osmosis and Nanotubes but they have contaminate byproducts.

MATERIALS AND METHODS

Theoretical considerations: The study was conducted in El Instituto Nacional de Investigaciones Nucleares (México) on 2006 and involves the desalination of the thermal geyser from Municipal hot-Baths of Ixtapan de la Sal, Mex. (México). On the process were used chemical reactions, ultrasound and flotation cell.

Table 1: Comparative study between thermal water of Ixtapan De La Sal, Mex. and seawater

Variables	Thermal water Ixtapan de la Sal composition (ppm)	Seawater composition (ppm)
NaCl	3,305.6	26,800.0
$CaSO_4$	1,222.5	1,200.0
KCl	201.4	700.0
$LiHCO_3$	9.7	
$Fe(HCO_3)_2$	0.6	
$NaHCO_3$	723.1	
$Mg(HCO_3)_2$	448.5	
$Mn(HCO_3)_2$	0.3	
$Ca(HCO_3)_2$	1,025.6	
KBr	0.4	
$Ca(NO_3)_2$	9.5	
$Na_2B_4O_7$	7.8	
SiO_2		28.8
$MgCl_2$		3,200.0
$MgSO_4$		2,200.0
NaBr		80.0
Colony forming units (mL)	45.0	
Another colony forming units (mL)	40.0	

Table 1 shows a comparative study between the thermal water of Ixtapan de la Sal, Mex. and seawater (Otomer, 1983). The thermal water on the geyser was 37°C.

Some physical properties of NaCl: The molecular dissociation of NaCl is very difficult because it is too much high stiff structure. The physical properties of NaCl are (http://chemed.chem.purdue.edu):

Fig. 1: A view of the experimental equipment

Phase at room temperature	Solid
Density	2.165 g cm^{-3}
Melting point	801°C
Boiling point	1413°C
Ability of aqueous solution to conduct Electricity	Conducts

Each Na^+ ion in NaCl is surrounded by six Cl^- ions and each Cl^- ion is surrounded by six Na^+.

Apparatus and procedure: The apparatus used were (Fig. 1):

- Ultramet II, Sonic cleaner, 100 watts, 55 kHZ
- Flotation cell, DENVER, Size D-1
- Conductivity meter, orion, mod. 145

The process involves a series of chemical reactions in order principally to dissociate the NaCl into sodium ion Na^+ and chloride ion Cl^-.

In the desalination technology, on one liter of brackish water Ag_2SO_4 and $CaSO_4$ were added and then, was excited by ultrasound and flotation cell. It was done in two steps each one of 1 h. At the end of the process the filtrate was analyzed for sulfate, nitrate, hardness, chloride, sodium, iron, silver, calcium, pH and bacteria concentration.

It was also obtained a calcium and sodium sulfate precipitated and AgCl also precipitated in which the silver is recovery using industrial methods and treated water. Because the equipment was designed under standards, this process can be scaled to a largest seawater desalination process.

Table 2: Comparative study between brackish water processed and some standards

Variables	Brackish water from Ixtapan de la Sal processed (ppm)	Norma Official Mexicana NOM-127-SSAI-1994 and Anonymous (1990)
SO^{-2}_4	10,350.00	400.00
NO^-_3	16.10	5.00
Total hardness ($CaCO_3$)	1,408.00	500.00
Total alkalinity		
PO^{-3}_4		
Cl^-	<1.00	250.00
Na^+	15.76	200.00
Fe	<0.10	0.30
Ag	2,986.00	0.05
Ca	377.00	600.00
pH	6.00	6.5-8.5
Bacteria concentration using		
Chemical reactions	0 cfu mL^{-1} (100% eliminated)	0 or not detected
Without chemical reactions	99.65% eliminated and 0.35% remaining as spores and fungus	0 or not detected

RESULTS AND DISCUSSION

According to drinkable water standards, it is important to note that the NaCl was totally dissociated and the values are under such standards. Using this results, it is possible to design new tests in order to have the best results for the silver and sulfates.

Another interesting thing is that, only the ultrasonic excitation of brackish water, was enough for to destroy the 99.65% of bacteria and using also the Ag_2SO_4, all bacteria were destroyed. It is important because, the brackish water treated is sterilized.

It is possible that, the conductivity was increased for the Ag^+ and SO_4^- that remain in the final water treated.

Table 2 presents a comparison between the brackish water processed and some standards.

Table 3 presents the percentage of NaCl and bacteria eliminated from the original Ixtapan water.

The conductivity was increased from original water 9,490. microsiemens/cm to treated water 10,130. microsiemens/cm:

- Using Ag_2SO_4 and $CaSO_4$ on the process, the bacterial colony was destroyed from 45 cfu mL^{-1} to 0.
- Without chemical reactions on the process and only excitation with ultrasound and flotation cell, the bacterial colony 40 cfu mL^{-1} was destroyed 99.65% and only remaining spores and fungus 0.35%.

The water desalination process on NaCl was satisfactory but because it is a preliminary study, it is necessary to design new tests in order to eliminate Ag^+ and SO_4^- from the treated water.

Table 3: Percentage of NaCl AND bacteria eliminated from the original ixtapan water

Variables	Original water composition (ppm)	Final treated water composition (ppm)	Percentage eliminated
SO^{-2}_4	940.00	10,350.00	
NO^{-}_3	0	16.10	
Total hardness	516.00	1,408.00	
Total alkalinity	183.00		
PO^{-3}_4	<1.00		
Cl^{-}	2112.00	<1.00	100.00
Na^{+}	1477.00	15.76	98.93
Fe	<0.10	<0.10	
Ag	0	2,986.00	
Ca	377.00		
pH	5.0	pH 6.0	
Cfu mL^{-1} = 45			
Using chemical reaction		0	100.00
Without chemical reaction		99.65%	99.65
Another original water Cfu mL^{-1} = 40		Eliminated and remaining 0.35% as spores and fungus	

The chemical reactions were also satisfactory and the ultrasonic and flotation cell excitation accelerated the process. The same process can be applied for seawater desalination, the difference is approximate 10 times more of NaCl.

The drinkable water standards are very restrictive for silver (0.05 ppm) on such a water but, the photographic industry has the process for recovery silver from photographic solutions by means of the metallic replacement and electrolytic process (Davis, 2001).

It can be a new and economic and efficient process because it is possible to recovery silver and only it is necessary to find the best parameters of time duration of process and reactive dose.

The sodium chloride was converted into AgCl precipitated and a dual precipitated of Ca and Na sulfate.

For economical problems, it was not possible to improve the process because it is necessary to design new tests in order to eliminate the Ag and SO_4 residual.

The process could be inexpensive because from AgCl it is possible to recovery the silver. And also, it is possible to recovery silver from the final solution because the photographic industry has the process for recovery silver from photographic solutions by means of the metallic replacement and electrolytic process (Davis, 2001).

- May be the conductivity was increased for the Ag and SO_4 residual.
- It is very important the bactericide action of the process because the final water could be drinkable. They were killed 100.00% of the original 45 cfu mL^{-1}.
- The bactericidal properties of the ultrasound also are very important because it is the confirmation of my doctorate degree named El ultrasonido como una radiación ionizante (Instituto Politécnico Nacional, México). From 40 cfu mL^{-1} were killed 99.65%, remaining 0.35% of the spores and fungus.
- Because the tests were done on standardization equipment, the process can be scaled to a largest seawater desalination.
- If the desalination process is good for the thermal water from Ixtapan de la Sal, also it is good for the seawater desalination because the chemical reactions are the same.

CONCLUSION

The preliminary study, is very important because, the NaCl was dissociated and this process can be applied for seawater desalination and only it is necessary to design new tests in order to eliminate the Ag^{+} and SO_4^{-} on the final water treated. It is possible to have a drinkable water without bacteria and fungus.

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