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Can European chloralkali industry benefit from local availability of best quality solar salt?

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Global Chlor-alkali and Vinyls Conference, 15-16.5.25, Hilton, Av. Diagonal, Barcelona, Spain

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Why this question?

European chlorine industry growth and prosperity is low for many reasons. Salt could be one of them.

If so, why?

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Salt production world-wide

Salt type	World production
Solar salt	160’000’000 t/y
Rock salt	120’000’000 t/y
Brines	100’000’000 t/y
Total	380’000’000 t/y

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Salt consumption world-wide

Salt user	Salt consumption
Chemical industry	220’000’000 t/y
Food	60’000’000 t/y
Other	100’000’000 t/y

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Salt Purities

	NaCl Purity (%)
Rock salt	90 - 97
Crude sea salt	97 - 99
Washed sea salt	99 – 99.5
Purified sea salt	99.5 – 99.8
Refined salt	99.8 – 99.9
Vacuum refined salt	99.9 – 99.95
Ultrapure salt	99.95 – 99.995

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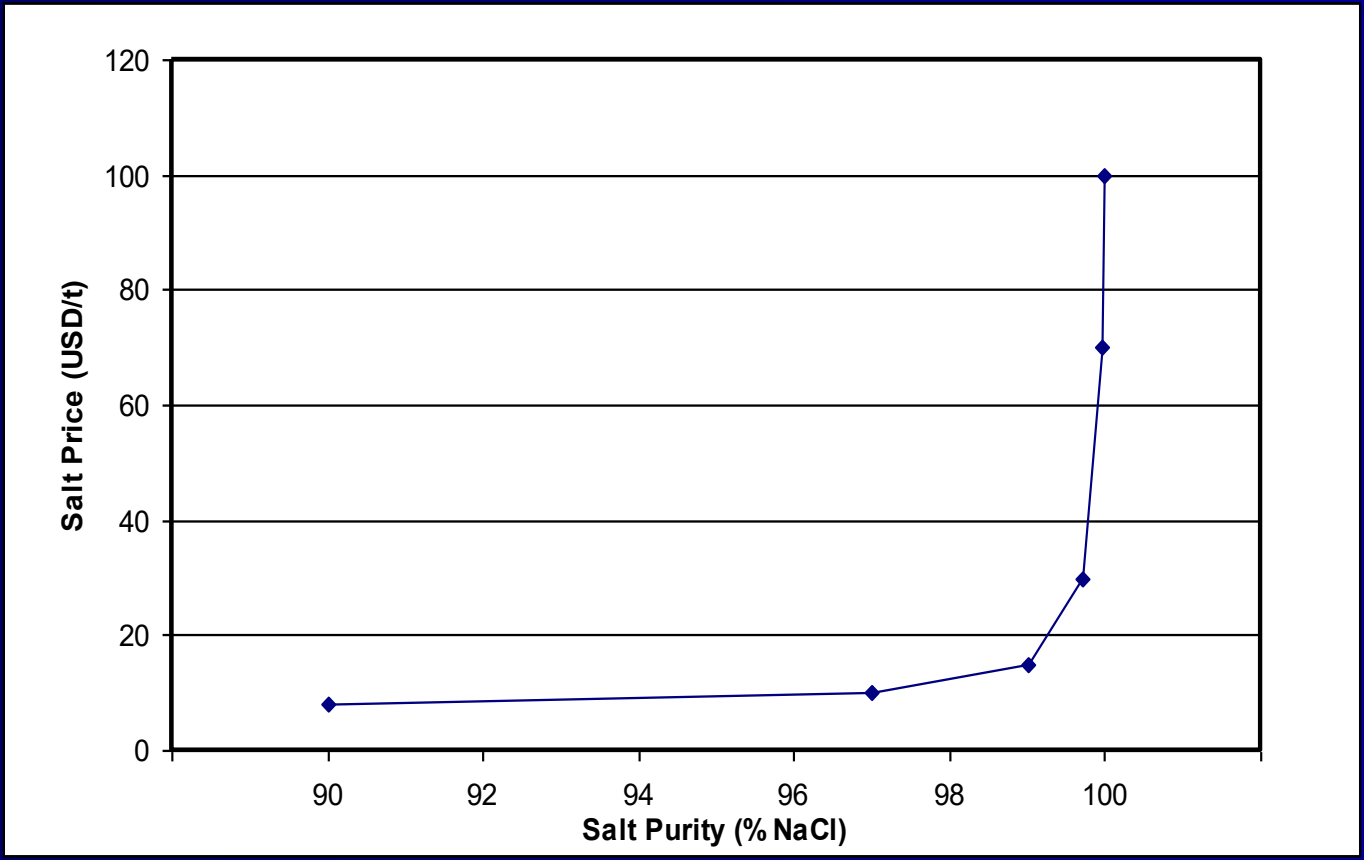
Salt Prices Depend on Salt Purity



Industrial salt FOB FOT prices vary between USD 10.-/t and USD 100.-/t depending on salt purity

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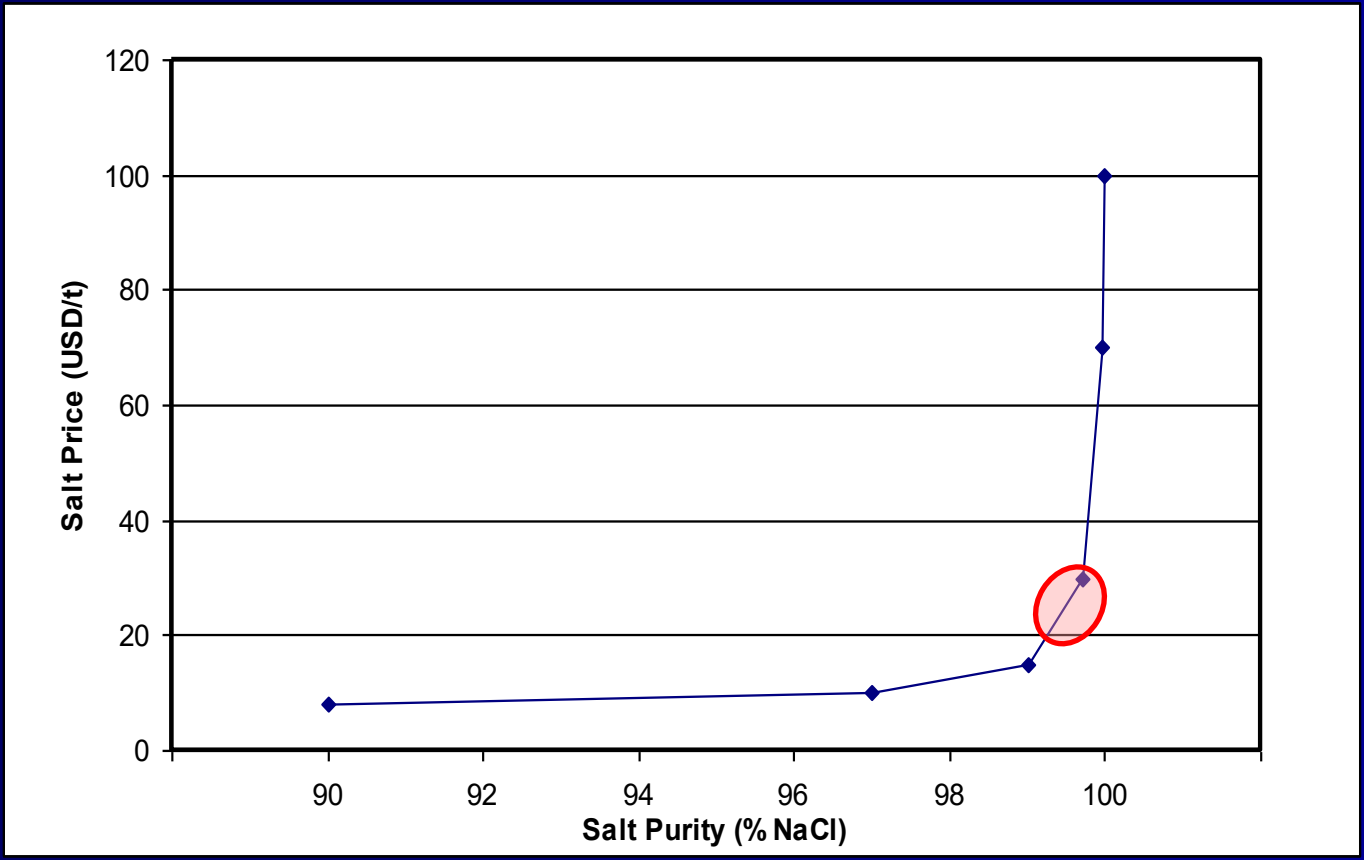
Salt Prices Depend on Salt Purity



Industrial salt FOB FOT prices vary between USD 10.-/t and USD 100.-/t depending on salt purity.

Aiming at 99.7% NaCl at USD 20.-/t to USD 30.-/t

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Worldwide salt business volume

Salt production	**380’000’000 t/y**
Average salt price (FOB, FOT)	**USD 50/t**
Total volume	**USD 19’000’000’000**

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Question:

Is high price of high purity salt for chlorine production justified?

If so, by how much?

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Important impurities in salt in 1996

	Rock salt	Sea salt	Lake salt	Brines
CaSO4	0.5 – 2%	0.5 – 1%	0.5 – 2%	Saturated
MgSO4	Traces	0.2 – 0.6%	Traces	Traces
MgCl2		0.3 – 1%	Traces	
CaCl2			Traces	
Na2SO4			Traces	
KCl			Traces	
NaBr			Traces	
Insolubles	1 – 30%	0.1 – 1%	1 – 10%	

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Important impurities in salt today

Ag, Al, As, Ba, Br, Ca, Cd, Cr, Cu, F, Fe, Hg, I, K, Li, Mg, Mn, Mo, N (as NH3 and as NO2), Ni, P, Pb, S (as SO4), Si (soluble), Si (total), Sr, Ti, V, Zn, TOC (Total Organic Carbon), THC (Total Hydro Carbons), Moisture, NORM (Naturally Occurring Radioactive Substances), Insolubles in 10% neutral brine, Insolubles in 2% neutral brine, Insolubles in alkaline brine, etc.

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Important impurities in brine for membrane cells

	Max.	Membrane Licensor A	Membrane Licensor B
Ca + Mg	ppb	20	20
SO4	g/l	5	4 - 8
I	ppm	0.1	0.2
Ba	ppm	0.1	0.5
Sr	ppm	0.4	0.1
Al	ppm	0.1	0.1
SiO2	ppm	5	5
Fe	ppm	0.05	0.1
Hg	ppm	0.1	0.1
Ni	ppm	0.01	0.01
Mn	ppm	-	0.01
F	ppm	-	0.5
TOC	ppm	10	10

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The Basic Chloralkali Equation (Chlorine)

Caustic and Chlorine from Salt

$$2\ NaCl + 2\ H_2O + \text{Electrical Energy} = 2\ NaOH + Cl_2 + H_2$$

119	36	82	71	2
1.45		1		
1.68			1	

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The Basic Chloralkali Equation (Soda)

Soda Ash from Salt and Lime

$$2\ NaCl + CaCO_3 = Na_2CO_3 + CaCl_2$$

119	110	111	120
1.1	0.93	1	

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Why must brine for chloralkali manufacture be pure?

- **Membrane damage in membrane cells**
- **Incrustations in soda ash production**
- **Contaminated effluents**
- **Bromine in chlorine for organic synthesis**
- **etc.**

Brine for chloralkali manufacture must be purified.

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Brine Purification: Ca and Mg Precipitation

Calcium precipitation	$Ca^{++} + Na_2CO_3 = \underline{CaCO_3} + 2\ Na^+$
	40 108
Magnesium precipitation	$Mg^{++} + 2\ NaOH = \underline{Mg(OH)_2} + 2\ Na^+$
	24 82

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Brine Purification: Overdosing of Reagents

For calcium precipitation	0.4 kg Na_2CO_3 per m3 of brine
For magnesium precipitation	0.15 kg NaOH per m3 of brine

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Brine Purification: Sulphate Removal

With $BaCO_3$	$SO4^{--} + BaCO_3 = \underline{BaSO_4} + CO_3^{--}$ 96 197 233
With $BaCl_2$	$SO4^{--} + BaCl_2 = \underline{BaSO_4} + 2\ Cl^-$ 96 208 233
With $CaCl_2$	$SO4^{--} + CaCl_2 = \underline{CaSO_4} + 2\ Cl^-$ 96 111 136
With Nanofiltration	From 4 – 8 g/l to 80 g/l in purge as Na2SO4

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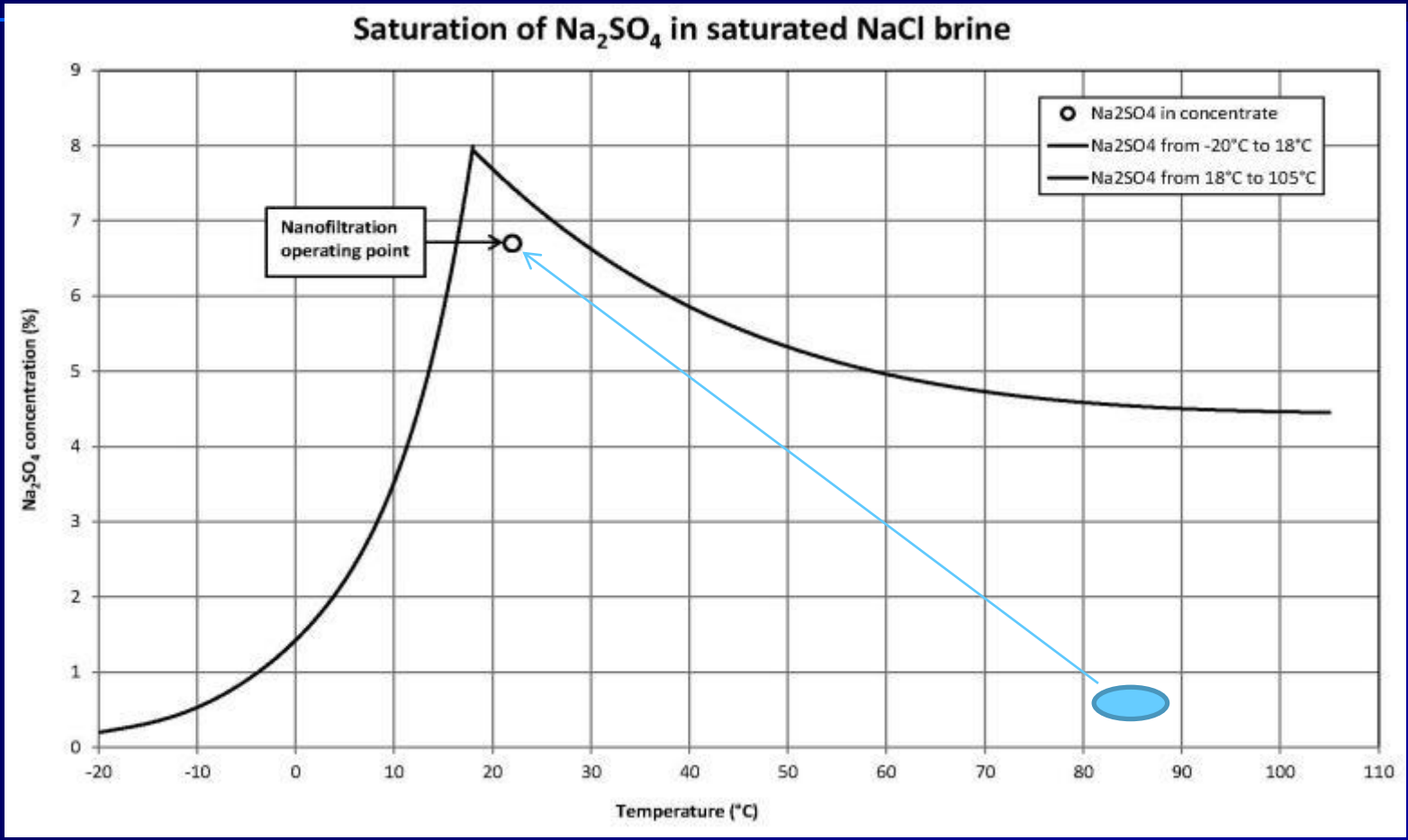
Nanofiltration Operating Point



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Salt Partners Cost Survey Contributors

SNEP, Morocco	Proinsal, Argentina	Solvay, Spain	Modi, India
Enichem, Italy	GACL, India	Grasim, India	Saukem, India
Standard Alkali, India	Bandar Imam, Iran	Chemfab, India	Century, India
NRC, India	Borregaard, Norway	GHCL, India	Heilbronn, Germany
Safi Salt, Jordan	Arab Potash, Jordan	Da Qing He, China	EPETCO, Egypt
Atul, India	MISR, Egypt	Quimpac, Peru	Azraq, Jordan
Dwory, Poland	Petkim, Turkey	TCC, India	Tata, India
Hellenic, Greece	Borsodchem, Hungary	Sind Alkalies, Pakistan	Frutarom, Israel
Nirou Clor, Iran	Kothari, India	Uniteca, Portugal	Ittehad, Pakistan
Aragonesas, Spain	Ercros, Spain	Shriram, India	Sitara, Pakistan
Saboo, India	Solvay, Argentina	Ballarpur, India	Salexpor, Portugal
Atanor, Argentina	Jayshree, India	Fine Salt, India	Tokuyama, Japan
Andhra Sugars, India	Emisal, Egypt	Sales Monzon, Spain	Reliance, India
Punta de Lobos, Chile	DCW, India	Tekel, Turkey	Salgema, Brazil
SPIC, India	Formosa Plastic	Rio Doce, Brazil	El Nasr, Egypt
Mabuhay Vinyl, Philippines	Arabian Chlorine, Saudi Arabia	Abadan Petrochemical, Iran	DSW, Israel

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Cost of Salt and Brine Treatment

	Cost of brine treatment and disposal (USD / t salt)	Cost of salt, brine treatment and disposal (USD / t salt)
Minimum	1.50	10
Average	10	25
Maximum	30	60

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Relative Brine Treatment Cost

	Cost of brine treatment as percentage of salt cost (%)	Percentage of chloralkali production cost (%)
Minimum	100	3
Average	170	15
Maximum	300	40

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40 t/h HYDROSAL salt purification plant producing ultrapure industrial salt

		Performance test
Ca	ppm	0.6
Mg	ppm	0.2
SO4	ppm	53

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High quality European vacuum salt "A" before and after purification

		Commercial vacuum salt product	HYDROSAL purified
Ca	ppm	< 1	< 1
Mg	ppm	0.12	0.07
SO4	ppm	118	29
K	ppm	87	72
Br	ppm	35	34
I	ppm	< 0.1	< 0.1
Ba	ppm	< 0.02	< 0.02
Sr	ppm	< 0.1	< 0.1
Al	ppm	< 0.05	< 0.05
SiO2	ppm	0.58	0.23

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High quality European vacuum salt "E" before and after purification

		Commercial vacuum salt product	HYDROSAL purified
Ca	ppm	6.5	5.8
Mg	ppm	3.1	2.9
SO4	ppm	191	33
K	ppm	36	29
Br	ppm	29	28
I	ppm	< 0.1	< 0.1
Ba	ppm	< 0.02	< 0.02
Sr	ppm	0.1	< 0.1
Al	ppm	< 0.05	0.05
SiO2	ppm	0.81	0.47

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High quality European vacuum salt "N" before and after purification

		Commercial vacuum salt product	HYDROSAL purified
Ca	ppm	211	66
Mg	ppm	6.8	1.2
SO4	ppm	820	229
K	ppm	225	185
Br	ppm	43	36
I	ppm	0.4	< 0.1
Ba	ppm	0.04	< 0.02
Sr	ppm	6.3	2.2
Al	ppm	1.0	0.1
SiO2	ppm	< 0.1	< 0.1

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Costs Related to Salt Use in Membrane Chloralkali Manufacture

- Salt Storage and Handling
- Salt Dissolution and Brine Purification
- Contaminated Sludge Handling and Disposal
- Purge Decontamination, Disposal and Salt Loss
- Ferrocyanide, Silica, Bromine and Iodine Removal
- Power Consumption
- Hydrochloric Acid Consumption
- Membrane Life
- Production Loss or Extra Production Capacity

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Comparative Study on Differential Costs in a Membrane Cell Plant having Following Parameters:

- Plant Capacity: 300’000 t/y of Chlorine
- Conversion from Mercury to Membranes
- Sulphate Removal with Nanofiltration
- Washed Salt with Bromine, Iodine and Ferrocyanide
- High Purity Salt without Bromine, Iodine and Ferrocyanide
- Primary Brine Purification Plant Redundant
- Membrane Cells with Acidification
- Production Loss or Extra Production Capacity

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Membrane Plant Operation with Salt A and B

		Washed Salt A	Ultrapure Salt B
Ca	(%)	0.1	0.00005
Mg	(%)	0.01	0.00001
SO4	(%)	0.4	0.005
Insolubles	(%)	0.5	0
Moisture	(%)	7	0.02
NaCl (dry basis)	(%)	98.9	99.995

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Membrane Plant Operation with Salt A and B

		Washed Salt A	Ultrapure Salt B
Salt cost (FOB, FOT)	(EUR/y)	14'820'000	23'010'000
Salt handling labour	(EUR/y)	330'000	300'000
Fuel	(EUR/y)	40'000	0
Salt handling maintenance	(EUR/y)	80'000	120'000
Process water	(EUR/y)	20'000	330'000
Brine purification chemicals	(EUR/y)	1'170'000	50'000
Primary brine purification power	(EUR/y)	330'000	0
Primary brine purification labour	(EUR/y)	330'000	0
Primary brine purif. maintenance	(EUR/y)	300'000	0
Solids disposal	(EUR/y)	770'000	0

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Membrane Plant Operation with Salt A and B

		Washed Salt A	Ultrapure Salt B
Nanofiltration plant cost	(EUR/y)	800’000	0
Nanofiltration power	(EUR/y)	120’000	0
Nanofiltration refrigeration water	(EUR/y)	20’000	0
Nanofiltration treated water	(EUR/y)	40’000	0
Nanofiltration reactants	(EUR/y)	50’000	0
Nanofiltration membrane replacement	(EUR/y)	40’000	0
Nanofiltration plant maintenance	(EUR/y)	60’000	0
Bromine removal	(EUR/y)	1’500’000	0
Ferrocyanide removal	(EUR/y)	0	0
Iodine removal	(EUR/y)	0	0

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Membrane Plant Operation with Salt A and B

		Washed Salt A	Ultrapure Salt B
Power consumption differential	(EUR/y)	0	- 830'000
Hydrochloric acid differential	(EUR/y)	0	- 980'000
Membrane life differential	(EUR/y)	0	- 220'000
Plant depreciation differential	(EUR/y)	0	- 720'000
Total	(EUR/y)	21'060'000	21'060'000
Salt price (FOB, FOT)	(EUR/t)	27.25	46.58
Salt price differential	(EUR/t)	-	+ 19.33
Salt price differential	(%)	-	+ 70.9

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Answer:

The presented example shows that high purity salt can be EUR 19.33/t or 70.9% more expensive than washed salt for the same economy.

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Conclusion:

European chloralkali industry could benefit from local availability of better quality solar salt, just like anywhere else in the world, if better quality would be available at lower price.

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Why not turn your salt into gold?

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