Membránové Inovační Centrum

MemBrain

Production of edible salt from Carlsbad thermal spring water by electrodialysis

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16.9.2013, PERMEA, Warszawa
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Carlsbad thermal springs

- Springs healing ability discovered by Václav Payer in 1522
- Located in the spa town of Karlovy Vary (Carlsbad), Czech Republic
- Positive effect on digestive tract (liver, stomach, intestine)
- Drinking and bathing cure, wellness procedures
- Drinking cure developed in 18th and 19th century by David Becher, Jean de Carro, Rudolf Mannl, Eduard Hlawacek
- 13 of 79 mineral thermal springs collected and used for drinking cure
- 153,894 spa guests in 2012

Objectives:

- **Production of solid crystalline Carlsbader salt for drinking cure at home**
- **(follow-up the spa treatment at home)**
- Food grade quality salt, easily soluble
- Capacity 20m^3 spring water daily (8h shift)
- Concentration technology cheaper than evaporator
- Waste water TDS concentration <2.5g/l (disposal limit, salt loss)

Feed:

- Carlsbader spring water
- Delivered in 10m^3 stainless steel tanks
- Pretreated and cooled down to 40°C

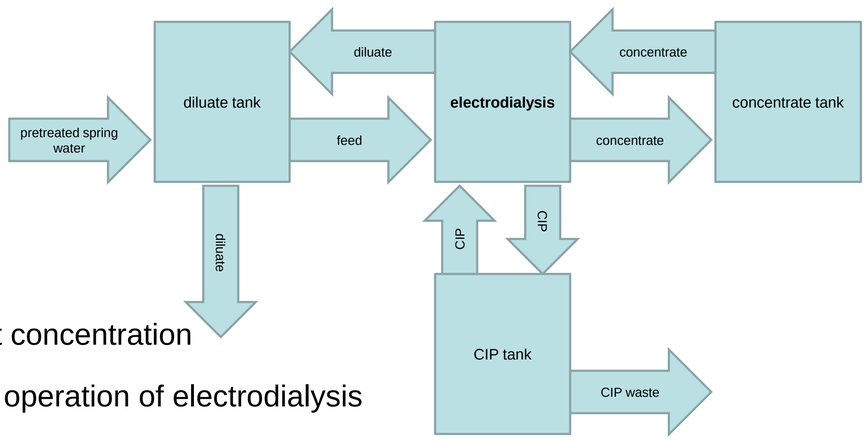
κ [mS/cm]	721
pH	8.58
TDS [mg/l]	5320
COD_{Cr} [mgO_2/l]	11.8
Ca^{2+} [mg/l]	1.51
Mg^{2+} [mg/l]	0.047
Ba^{2+} [mg/l]	<0.0005
Sr^{2+} [mg/l]	<0.001
Na^{+} [mg/l]	1943
K^{+} [mg/l]	0.56
Li^{+} [mg/l]	0.402

NH_4^{+} [mg/l]	<0.02
Cl^{-} [mg/l]	588
SO_4^{2-} [mg/l]	1610
HCO_3^{-} [mg/l]	2000
CO_3^{2-} [mg/l]	30.3
F^{-} [mg/l]	6.28
NO_3^{-} [mg/l]	<0.5
Total Si [mg/l]	43.4
Total P [mg/l]	0.06
Total Fe [mg/l]	0.06
Total Mn [mg/l]	0.001

Feed water analysis

ED design by laboratory tests

- ED unit P EDR-Z/10-0.8 with 0.064m^2 active membrane area (own production)
- Membranes: anion exchange Ralex® AMH-PES, cation exchange Ralex® CMH-PES
- Estimation of concentrate conductivity limit (salt precipitation)
  - Gradual increase of concentrate conductivity until scaling occurs (visual control of disassembled ED stack), 7 batch tests
- Estimation of ED capacity dependence on diluate conductivity
  - Batch test at concentrate conductivity limit
- Scale-up to industrial size unit (own production)



Technology overview:

- Electrodialysis for salt concentration
- Diluate tank for batch operation of electrodialysis
- Concentrate tank for product storage prior transport to evaporator
- Desalinated water (diluate) discharged to the drain after each batch
- CIP tank for ED chemical cleaning and conservation

ED design:

- ED unit P2 2xEDR-X/100-0.8 with 18.9m^2 of active membrane area
- Temperature: <40°C controlled by operator (PE limits)
- Voltage: 1.5V/cell
- Circulation flowrate: 5m3/h for both diluate and concentrate
- Safety filter: 100μm (Fe) for both diluate and concentrate
- Manual batch start
- Automatic batch control (batch end, constant concentrate conductivity, voltage and current limits)

ED product:

- Concentrated aqueous salt stream
- $NaHCO_3$ type
- Detail composition --->
- **19x concentrated**
  - ✓ low volume
  - ✓ low transport costs

Density	kg/m^3	1052
Conductivity	mS/cm	61.8
pH		8.57
TDS (105°C)	mg/l	102000
TS (180°C)	mg/l	62220
TDS (550°C)	mg/l	61400
TSS	mg/l	112
Na^{+}	mg/l	24000
K^{+}	mg/l	1070
Ca^{2+}	mg/l	8.07
Mg^{2+}	mg/l	17.3
Ba^{2+}	mg/l	0.685

Sr^{2+}	mg/l	0.11
SO_4^{2-}	mg/l	20500
Cl^{-}	mg/l	7950
F^{-}	mg/l	93.2
HCO_3^{-}	mg/l	20400
CO_3^{2-}	mg/l	1360
CO_2 total	mg/l	17600
P total	mg/l	N/A
Fe total	mg/l	0.488
Mn total	mg/l	0.05
$CHSK_{Cr}$	mg/l	1440

ED product analysis

Final product:

- Evaporate and dry ED product
- Dry solid Carlsbader salt, 3g/package
- To follow-up the drinking cure at home
- Drinking dissolved in tap water at 0,4-5,2% concentration
- Mineral water production at 0,3-1,5g/l
- Additive for food industry (bakery, pastry)

Major ions	g/kg	Trace elements	mg/kg
Na^{+}	314.0	Li^{+}	440
K^{+}	13.7	Ca^{2+}	394
SO42-	275.0	Si	388
HCO_3^{-}	241.0	Mg^{2+}	95.5
Cl^{-}	104.0	P	12.1
CO_3^{2-}	42.6	Fe	6.36
		Mn	0.34
		Ba^{2+}	0.30

Final product analysis

Conclusion:

- Industrial ED unit design based on laboratory ED tests
- Scale-up ratio 300:1 still working OK for ED
- Salt produced by the company Original Karlsbader Sprudelsalz since May 2012
- No problems with the technology yet