Claims

1. A method for producing mineralized water, comprising:

a) providing a saline water comprising ions, including carbonate ions, magnesium ions and calcium ions.

b) treating said saline water comprising ions by desalination to produce a desalinated water and a brine, the desalinated water being depleted in said ions initially contained in said saline water and the brine being concentrated in said ions initially contained in said saline water, the desalination being a reverse osmosis step,

c) performing a step of carbonates removal on at least part of said brine of step b) to produce gaseous CO_2 and a brine depleted in carbonate ions,

d) performing a crystallization on the brine of step c) depleted in carbonate ions to produce (i) at least one mineral product chosen from a magnesium-containing mineral and a calcium-containing mineral, and (ii) a treated solution at least partially depleted in ions chosen from calcium and/or magnesium ions, in which the crystallization step is implemented in two crystallization steps :

d1) a first step of crystallization performed at a controlled pH from 9 to 11.5 to produce a first mineral product containing magnesium and the first treated solution with a reduced content of magnesium ions,

d2) a second step of crystallization of said first treated solution performed at a controlled pH from 11.5 to 14 to produce a second mineral product containing both calcium and magnesium and the second treated solution depleted in both calcium and magnesium ions,

e) remineralizing the desalinated water produced in step b), said remineralizing comprising adding at least part of said at least one mineral product and at least part of said gaseous CO_2 to at least part of said desalinated water to produce a mineralized desalinated water.

2. The method of claim 1, wherein said step of carbonates removal comprises:

c11) a step of adjusting the pH of the brine concentrated in said ions to a value of 7 or less to produce an acidified brine and carbonic acid, and

c12) a step of separating CO_2 from the acidified brine to produce gaseous CO_2 and a brine depleted in carbonate ions.

3. The method of claim 1, wherein said step of carbonates removal comprises:

c11) an optional step of adjusting the pH of the brine concentrated in said ions to a value of 7 or less to produce an acidified brine,

c22) a step of heating the brine concentrated in said ions or the acidified brine to a temperature of 40 °C or more to produce a heated brine, gaseous CO_2 and scale, and

c23) a step of separating the gaseous CO_2 and scale from the heated brine to produce a brine depleted in carbonate ions and gaseous CO_2.

4. The method of any of claims 1 to 3, further comprising a step for recovering at least a part, optionally all, of said first mineral product comprising magnesium.

5. The method of any of claims 1 to 4, further comprising, prior to said step of remineralization, a step of mixing said at least one mineral product with at least a portion of said desalinated water, optionally with pH adjustment, to produce a mineral containing aqueous solution which is then mixed with the rest of the desalinated water in the remineralization step to obtain a desalinated water enriched in mineral products.

6. The method according to any of claims 1 to 5, wherein the first mineral product in the first crystallization step is magnesium hydroxide.

7. The method according to any of claims 1 to 6, wherein the second mineral product in the second crystallization step is a mixture of calcium- and magnesium-hydroxides.

8. The method according to any of claims 1 to 7, comprising at least one of the following features:

- at least a part of said first mineral product is used for the remineralization step e),
- at least a part of said second mineral product is used for the remineralization step e).

9. The method according to any of claims 1 to 8, further comprising a step of electrochemical treatment of said second depleted treated solution produced in

the crystallisation step, to produce an acidic solution, a basic solution, and a solution with a lower content of sodium chloride.

10. The method of claim 9 in which said electrochemical treatment is an electrodialysis with bipolar membranes.

11. The method of claims 9 or 10, in which said acidic solution and/or a basic solution is used:

- to adjust the pH of the saline water before the desalination step to avoid scaling formation, and/or,
- to adjust the pH of at least a portion of the desalinated water used in said mixing step performed before the remineralization step for dissolving at least part of said at least one mineral product or said second mineral product comprising magnesium and calcium minerals, and/or
- to adjust the pH of the brine in the carbonates removal step, and/or
- as reagent in the crystallization step.

12. The method of any of claims 9 to 10, in which said solution with a lower content of sodium chloride is mixed to the saline water, especially prior to the desalination step.

13. An installation (100, 200, 300, 400, 500) for providing mineralized water, comprising at least:

- a reverse osmosis unit (MF) comprising at least a first inlet (I_{MF1}), a first outlet (O_{MF1}) and a second outlet (O_{MF2}), said reverse osmosis unit being configured to be fed at said first inlet inlet (I_{MF1}) with saline water (1) comprising ions, including carbonate ions, magnesium ions and calcium ions, and to produce a desalinated water (2) recovered at said first outlet (O_{MF1}) and a brine (3) recovered at said second outlet (O_{MF2}), said desalinated water being depleted in said ions initially contained into said saline water and said brine being concentrated in said ions initially contained into said saline water,
- a carbonates removal unit (UrC) for removing carbonate ions comprising at least a first inlet (I_{UrC1}) fluidly coupled to the second outlet (O_{MF2}) of the reverse osmosis unit, a first outlet (O_{UrC1}) and a second outlet (O_{UrC2}), said carbonates removal unit being configured to remove carbonate ions from said brine (3) fed

at said first inlet (I_{UrC1}) and to produce gaseous CO_2 recovered at the first outlet (O_{UrC1}) and a brine (4) depleted in carbonate ions recovered at the second outlet (O_{UrC2}),

- a crystallization unit (Cr) comprising at least a first inlet (I_{Cr1}) fluidly coupled to the second outlet (O_{UrC2}) of the carbonates removal unit, a first outlet (O_{Cr1}) and a second outlet (O_{Cr2}), the crystallization unit being configured to be fed at the first inlet (I_{Cr1}) with the brine (4) depleted in carbonate ions and to crystallize (i) at least one mineral product (5) chosen from a magnesium-containing mineral and a calcium-containing mineral recovered at the first outlet (O_{Cr1}), and to produce (ii) a depleted treated solution (6) at least partially depleted in ions chosen from calcium and/or magnesium ions recovered at the second outlet (O_{Cr2}),
- a remineralization unit (RM) comprising at least a first inlet (I_{RM1}) fluidly coupled to the first outlet (O_{MF1}) of the reverse osmosis unit, a second inlet (I_{RM2}) fluidly coupled to the first outlet (O_{UrC1}) of the carbonates removal unit and a third inlet (I_{RM3}) fluidly coupled to the first outlet (O_{Cr1}) of the crystallization unit, and a first outlet (O_{RM1}), the remineralization unit being configured to mix at least part of the desalinated water (2) fed at the first inlet (I_{RM1}), at least part of the CO_2 fed at the second inlet (I_{RM2}) and at least part of said at least one mineral product (5) fed at the third inlet (I_{RM3}) to produce a mineralized desalinated water (7) recovered at the first outlet (O_{RM1}),

in which the crystallization unit (Cr) comprises:

- a single crystallization capacity comprising at least said first inlet (I_{Cr1}), first outlet (O_{Cr1}) and second outlet (O_{Cr2}) and a duct fluidly coupling the second outlet to the first inlet, or
- two crystallization capacities (CrA, CrB), a first crystallization capacity comprising at least said first inlet (I_{CrA1}), first outlet (O_{CrA1}) and second outlet (O_{CrA2}), and configured to be fed at its first inlet (I_{CrA1}) with the brine (4) depleted in carbonate ions to produce a first mineral product (5-1) recovered at the first outlet (O_{CrA1}) and a first treated solution depleted in ions (6-1) recovered at its second outlet (O_{CrA2}), and a second crystallization capacity (CrB) comprising at least a first inlet (I_{CrB1}) fluidly coupled to the second outlet (O_{CrA2}) of the first crystallization capacity, a first outlet (O_{CrB1}) and a second outlet (O_{CrB2}) and configured to be fed at its first inlet (I_{CrB1}) with the first treated solution depleted in ions (6-1) to recover a second mineral product (5-2) at its first outlet (O_{CrB1}) and a second treated solution (6-2) at its second outlet (O_{CrB2}).

14. The installation (300, 400, 500) of claim 13, further comprising :

- an electrochemical unit (EL) comprising at least a first inlet (I_{EL1}), a first outlet (O_{EL1}), a second outlet (O_{EL2}), and a third outlet (O_{EL3}), the first inlet (I_{EL1}) being fluidly connected to the second outlet (O_{Cr2}) of said crystallisation unit or to the second outlet of the single crystallization capacity or to the second outlet(O_{CrB2}) of the second crystallization capacity, and the electrochemical unit being configured to produce an acidic solution (8) at its first outlet (O_{EL1}), a basic solution (10) at its second outlet (O_{EL2}) and a solution (11) with a lower content of sodium chloride at its third outlet (O_{EL3}).

15. The installation (300, 400, 500) of claim 14, wherein :

at least one of the first and second outlets of the electrochemical unit is fluidly coupled to :

- a pH adjusting unit (504) fluidly connected to the first inlet of the reverse osmosis unit to adjust the pH of the saline water before its entry into the reverse osmosis unit, and/or
- the reverse osmosis unit (MF) to adjust the pH of the desalinated water, and/or
- a mixing unit (503) to adjust the pH of an aqueous solution used for dissolving at least part of said at least one mineral product or said second mineral product comprising magnesium and calcium minerals, said mixing unit comprising a first inlet fluidly connected to the first outlet of crystallization unit or to the first outlet of the first crystallization capacity or to the first outlet of the second crystallization capacity, and a first outlet fluidly connected to the third inlet of the remineralization unit, and/or
- to the carbonates removal unit to adjust the pH of the brine, and/or
- to the crystallization unit,

and/or,

the third outlet of the electrodialysis unit is fluidly coupled to:

- a mixing unit fluidly connected to the first inlet of the reverse osmosis unit to mix said solution with a lower content of sodium chloride with the saline water prior to its entry into the reverse osmosis unit.