CLAIMS

What is claimed is:

1. A process for treating saline water to obtain product water comprising a higher concentration of divalent ions (i) $Mg^{2+}$and/or Ca^{2+}; and (ii) SO_4^{2-} as compared with said saline water, the process comprising the steps of:

    a. passing a sample of saline water through a first nanofiltration (NF) membrane to obtain an NF permeate and an NF retentate (NF brine);

    b. passing the NF brine obtained in step (a) through a second NF membrane in the presence of a diluting solution (diaNanofiltration (diaNF) mode), to obtain a diaNF permeate and a diaNF retentate (diaNF brine);

    c. optionally subjecting the diaNF brine obtained in step (b) to one or more additional diaNF cycles in the presence of a diluting solution; and

    d. isolating the diaNF brine from step (b) or optional step (c) as product water having a higher concentration of said divalent ions, and a lower concentration of species selected from the group consisting of Na^+, Br^-, Cl^- and B as compared with said saline water.

2. The process according to claim 1, further comprising the step of passing the product water through at least one ultrafiltration (UF) membrane.

3. The process according to claim 1, further comprising the step of de-carbonating the saline water prior to the NF step (a).

4. The process according to claim 1, wherein the saline water is selected from the group consisting of sea water, brackish water and seawater reverse osmosis (SWRO) brine.

5. The process according to claim 1, wherein the diluting solution is selected from the group consisting of low total dissolved solids (TDS) water, soft water, distilled water, tap water, NF permeate, SWRO permeate, and brine obtained after multiple SWRO stages.

6. The process according to claim 1, wherein the recovery ratio (RR) of the NF step (a) is between 40 and 85%.

7. The process according to claim 1, wherein an anti-scalant is added to the saline water.

8. The process according to claim 1, comprising between 1 and 6 diaNF cycles.

9. The process according to claim 1, wherein the permeate of the last diaNF cycle(s) for a given batch of saline water is recycled and used as the diluting solution of the first diaNF cycle(s) of the next batch of saline water.

10. The process according to claim 1, wherein the diluting solution of the last DiaNF cycle(s) is SWRO permeate, distilled water or fresh water.

11. The process according to claim 1, wherein the diluting solution of the first DiaNF cycle(s) is brine obtained after multiple SWRO stages.

12. The process according to any one of the preceding claims, wherein the NF and diaNF cycles use the same type of NF membrane.

13. The process according to any one of the preceding claims, wherein the NF and diaNF cycles use different types of NF membrane.

14. The process according to any one of the preceding claims, wherein the NF membrane is selected from the group consisting of DL, DK, NF90, NF245, NF270 and TS80.

15. The process according to any one of the preceding claims, wherein the NF membrane preferentially rejects Ca^{+2} and/or Mg^{2+} ions over Na^{+}, Br^{-}, Cl^{-} and B species.

16. The process according to any one of the preceding claims, wherein the permeates from the NF and diaNF cycle(s) are combined and recycled back to a desalination plant.

17. The process according to any one of the preceding claims, further comprising the step of lowering the $Mg^{2}+Ca^{2+}:SO_4^{2-}$ concentration ratio in the product water as compared with the saline water.

18. The process according to claim 17, wherein the $Mg^{2+}+Ca^{2+}:SO_4^{2-}$ concentration ratio is lowered by reducing the Mg^{2+} and Ca^{2+}concentrations in the product water.

19. The process according to claim 18, wherein the Mg^{2+} and Ca^{2+}concentrations are reduced by employing in step (a) a membrane which preferentially rejects SO_4^{2-} over Mg^{2+} and Ca^{2+}.

20. The process according to claim 18, wherein the Mg^{2+} and Ca^{2+} concentrations are reduced by performing a cation exchange step between the NF and diaNF cycles.

21. The process according to claim 17, wherein the Mg^{2+}+Ca^{2+}:SO_4^{2-} concentration ratio is lowered by increasing the SO_4^{2-} concentration in the product water.

22. The process according to claim 21, wherein the SO_4^{2-} concentration is increased by adding a SO_4^{2-} source to the feed of the DiaNF step.

23. The process according to claim 21, wherein SO_4^{2-} concentration is increased by performing an anion exchange step between the NF and diaNF cycles.

24. The process according to any one of claims 17 or 23, wherein the Mg^{2+}+Ca^{2+}:SO_4^{2-} ratio in the saline water is about 2:1, and is lowered to between 1.25:1 and 1:1 in the product water.

25. The process according to anyone of claims 17 to 24, which results in the reduction or elimination of Cl^- ions in the product water.

26. The process according to any one of the preceding claims, wherein the Cl^- to Mg^{2+} concentration ratio is at least about 10:1 (w/w), preferably at least about 15:1 (w/w) in the saline water, and lower than about 5:1 (w/w), preferably lower than about 1:1 (w/w) in the product water.

27. The process according to claim 26, wherein the Cl^- to Mg^{2+} concentration ratio in the product water is lower than about 1:1 (w/w), preferably wherein the Cl^- concentration in the product water is close to 0%.

28. The process according to any one of the preceding claims, wherein the Na^+ to Mg^{2+} concentration ratio is at least about 5:1 (w/w), preferably at least about 7.5:1 (w/w) in the saline water, and about 1:1 (w/w) or lower in the product water.

29. The process according to claim 28, wherein the Na^+ to Mg^{2+} concentration ratio in the in the product water is lower than about 1:1 (w/w), preferably wherein the Na^+ concentration in the product water is close to 0%.

30. The process according to any one of the preceding claims, wherein the NF step (a) is preceded by one or more diaNF dilution cycles.

31. The process according to any one of the preceding claims, further comprising the step of adding the product water obtained in step (d) to a water sample so as to supplement said water sample with Mg^{2+} and, Ca^{2+}, and/or SO_4^{2-}.

32. A process for supplementing water with Mg^{2+} and/or Ca^{2+}, the process comprising the step of adding to the water an aliquot of product water produced by the process according to any one of the preceding claims.

33. The process according to claim 32, wherein the water being supplemented is desalinated water, soft water, drinking water or irrigation water.

34. A system for treating saline water to produce product water comprising a higher concentration of divalent ions (i) $Mg^{2+}$and/or Ca^{2+}; and (ii) SO_4^{2-} as compared with said saline water, the system comprising:

a. a nanofiltration (NF) module comprising a first NF membrane, an inlet for a feed stream, an outlet for a NF permeate stream and an outlet for a NF retentate (NF brine) stream;

b. at least one diaNanofiltration (diaNF) module, each module comprising a second NF membrane, an inlet for the NF retentate stream obtained in step (a), an inlet for a diluting solution stream, an outlet for a diaNF permeate stream and an outlet for a diaNF retentate (diaNF brine) stream;

c. optionally, an ultrafiltration (UF) module comprising an UF membrane, an inlet for the diaNF brine stream obtained in step (b), and an outlet for a UF product stream; and

d. a receiving tank for isolating the diaNF brine obtained in step (b) or the UF product stream obtained in optional step (c), the brine/UF product stream being

product water having a higher concentration of the divalent ions, and a lower concentration of species selected from the group consisting of Na^+, Br^-, Cl^- and B as compared with the saline water.

35. The system according to claim 34, further comprising a connector for recycling the diaNF brine obtained in step (b) for multiple cycles (i.e., additional dilution volumes) of diaNF.

36. The system according to claim 34, further comprising a connector for recycling the permeate from the last diaNF cycle as the diluting solution of the first DiaNF cycle of the next batch of saline water.

37. A process for treating saline water to obtain product water comprising a higher concentration of divalent ions selected from the group consisting of Mg^{2+}, Ca^{2+} and SO_4^{2-} as compared with said saline water, the process comprising the steps of:

a. decarbonating a sample of saline water;

b. passing the sample of saline water obtained in step (a) through a first nanofiltration (NF) membrane to obtain an NF permeate and an NF retentate (NF brine);

c. passing the NF brine obtained in step (b) through a second NF membrane in the presence of a diluting solution (diaNanofiltration (diaNF) mode), to obtain a diaNF permeate and a diaNF retentate (diaNF brine);

d. optionally subjecting the diaNF brine obtained in step (c) to one or more additional diaNF cycles in the presence of a diluting solution; and

e. isolating the diaNF brine from step (c) or optional step (d) as product water having a higher concentration of said divalent ions, and a lower concentration of species selected from the group consisting of Na^+, Br^-, Cl^- and B as compared with said saline water.

38. A process for treating saline water to obtain product water comprising a higher concentration of divalent ions selected from the group consisting of Mg^{2+}, Ca^{2+} and SO_4^{2-} as compared with said saline water, the process comprising the steps of:

a. passing a sample of saline water through a first nanofiltration (NF) membrane to obtain an NF permeate and an NF retentate (NF brine);

b. passing the NF brine obtained in step (a) through a second NF membrane in the presence of a diluting solution (diaNanofiltration (diaNF) mode), to obtain a diaNF permeate and a diaNF retentate (diaNF brine);

c. optionally subjecting the diaNF brine obtained in step (b) to one or more additional diaNF cycles in the presence of a diluting solution;

d. isolating the diaNF brine from step (b) or optional step (c) as product water having a higher concentration of said divalent ions, and a lower concentration of species selected from the group consisting of Na^{+}, Br^{-}, Cl^{-} and B as compared with said saline water; and

e. adding the product water obtained in step (d) to a water sample so as to supplement said water sample with Mg^{2+} and/or Ca^{2+}, and SO_4^{2}.