CLAIMS

1. A system comprising:

a reverse osmosis (RO) membrane module having an inlet, a permeate outlet, and a concentrate outlet, the RO membrane module being operable to separate a feed into a RO permeate and a RO concentrate, the RO concentrate being delivered out of the RO membrane module via the concentrate outlet;

a first tank;

a second tank;

a pump; and

a fluid circuit, the fluid circuit coupling the RO membrane module, the pump, the second tank, and the first tank, the fluid circuit being configured to provide a flow path including:

a first feed flow path directing the feed to the inlet;

a first concentrate flow path directing the RO concentrate from the concentrate outlet to the first tank;

a second feed flow path directing the feed from the first tank to the inlet, wherein the first feed flow path and the second feed flow path are configured to receive the feed from different sources, wherein the fluid circuit is configured to alternate between providing the first feed flow path in a first cycle and providing the second feed flow path in a second cycle, the first cycle and the second cycle being successive cycles of at least two cycles of liquid through the RO membrane module,

the fluid circuit comprising:

a first three-way valve, the first three-way valve being coupled to the first tank, the second tank, and the pump, the pump being coupled to the inlet of the RO membrane module, the first three-way valve enabling the feed received by the pump is from no more than one of the first tank and the second tank at any one time; and

a second three-way valve, the second three-way valve being coupled to the concentrate outlet, the first tank, and the second tank, the second three-way valve enabling the RO concentrate delivered out of the concentrate outlet to be directed to only one of the first tank and the second tank at any one time,

wherein the fluid circuit is devoid of a flow path connecting the concentrate outlet to the inlet

other than via the first tank and the second tank, the first tank and the second tank being not connected to one another by a fluid delivery conduit bypassing the RO membrane module,

and wherein: in the first cycle, the feed is received from the second tank and directed along the first feed flow path to the RO membrane module, the second tank serving as a feed tank in the first cycle; and in the first cycle, the RO concentrate is directed along the first concentrate flow path from the RO membrane module to the first tank, the first tank serving as a receiver tank in the first cycle,

and wherein: in the second cycle, the feed is received from the first tank and directed along the second feed flow path to the RO membrane module, the first tank serving as the feed tank in the second cycle; and in the second cycle, the RO concentrate is directed along a second concentrate flow path from the RO membrane module to the second tank, the second tank serving as the receiver tank.

2. The system according to claim 1, wherein in the first cycle, the first feed flow path and the first concentrate flow path do not converge upstream of the inlet and downstream of the second tank, and wherein in the second cycle, the second feed flow path and the second concentrate flow path do not converge upstream of the inlet and downstream of the first tank.

3. The system according to claim 1 or claim 2, wherein the RO concentrate of a current cycle is prevented from mixing with the feed of the current cycle, the current cycle being any one of the at least two cycles.

4. The system according to claim 3, wherein each of the first tank and the second tank is configured to alternately serve as the feed tank to provide the feed in the current cycle and as the receiver tank to receive the RO concentrate in a subsequent cycle, the subsequent cycle immediately following the current cycle.

5. The system according to any one of claims 1 to 4, wherein the fluid circuit is configured to prevent a direct flow path of liquid from the receiver tank to the feed tank within each of the at least two cycles, in which the direct flow path does not pass through the RO membrane module.

6. The system according to any one of claims 1 to 5, wherein the RO concentrate out of the RO membrane module is characterized by an osmotic pressure for each of the at least two cycles, and wherein the feed of each cycle is delivered to the inlet at a target pressure, the target pressure being controllably variable between any of the at least two cycles such that the target pressure is at least minimally greater than the osmotic pressure of the RO concentrate out of the RO membrane module in the current cycle.

7. The system according to any one of claims 1 to 6,

wherein the pump is configured to progressively increase the target pressure with each of the successive cycles.

8. The system according to claim 7,

wherein the pump is configured to alternate between (i) receiving the feed from the second tank in the first cycle and (ii) receiving the feed from the first tank in the second cycle.

9. The system according to any one of claims 6 to 8, further comprising:

an energy recovery device coupled to the fluid circuit, the energy recovery device being configured to recover energy from the RO concentrate, wherein the energy recovery device is configured to at least partially pressurize the feed.

10. The system according to any one of claims 1 to 9, wherein the fluid circuit further comprises a fresh feed inlet configured to receive one intake of fresh feed, and wherein the one intake of fresh feed is cycled through the RO membrane module for the at least two cycles.

11. The system according to claim 10, wherein the system is configured to initiate a discharge of remaining liquid in the fluid circuit and in any of the first tank and the second tank, and wherein the discharge is initiated in response to a recovery parameter reaching a threshold value.

12. The system according to claim 11, wherein the recovery parameter is determined based on a condition of the RO permeate at the permeate outlet, a condition of the feed, a condition of the RO concentrate out of the RO membrane module, a specific energy consumption, a number of cycles, a permeate flowrate, or any combination thereof.

13. The system according to any one of claims 1 to 12, further comprising a treatment unit, the treatment unit being configured to provide at least one chemical dosage to respective contents of one or both of the feed tank and the receiver tank.

14. The system according to claim 13, wherein the treatment unit comprises one or more third tank configured to receive the RO concentrate from the RO membrane module and to deliver a treated concentrate to the receiver tank, wherein the treatment unit is configured to provide the at least one chemical dosage to the one or more third tank and to provide for at least partial settlement of non-dissolvable particles in the one or more third tank before the treated concentrate is delivered to the receiver tank.

15. The system according to claim 13, further comprising a filtration unit coupled to the fluid circuit, the filtration unit being configured to filter the feed received from the feed tank.

16. The system according to any one of claims 1 to 12, further comprising a secondary membrane module coupled to the fluid circuit, wherein the secondary membrane module is operable to separate the RO concentrate from the RO membrane module into a secondary permeate and a secondary retentate, the secondary permeate being received by the receiver tank.

17. The system according to claim 16, wherein the fluid circuit is configured to recover energy from the secondary retentate before discharging the secondary retentate.

18. The system according to any one of claims 1 to 17, wherein the RO membrane module comprises one or more RO membranes, and wherein at least one of the one or more RO membranes is characterized by a rejection rate of 80% sodium chloride rejection rate or above 80% sodium chloride rejection rate.

19. A method comprising:

directing a feed along a first feed flow path in a fluid circuit, the fluid circuit being configured to provide a flow path in a system including a first tank and a reverse osmosis (RO) membrane module, the RO membrane module having an inlet, a permeate outlet, and a concentrate outlet, the RO membrane module being operable to separate the feed into a RO permeate and a RO concentrate;

directing the RO concentrate along a first concentrate flow path from the concentrate outlet to the first tank; and

directing the feed along a second feed flow path from the first tank to the inlet, wherein the first feed flow path and the second feed flow path are configured to receive the feed from different sources, and wherein the flow path includes the first feed flow path, the first concentrate flow path, and the second feed flow path;

alternating between providing the first feed flow path in a first cycle and providing the second feed flow path in a second cycle, the first cycle and the second cycle being successive cycles of at least two cycles of liquid through the RO membrane module,

wherein the first cycle includes receiving the feed from a second tank and directing the feed along the first feed flow path to the RO membrane module, the second tank serving as a feed tank in the first cycle; and

wherein the first cycle includes directing the RO concentrate along the first concentrate flow path from the RO membrane module to the first tank, the first tank serving as a receiver tank in the first cycle, and

wherein the second cycle includes receiving the feed from the first tank and directing the feed along the second flow path from the first tank to the RO membrane module,

the first tank serving as the feed tank in the second cycle; and

wherein the second cycle includes directing the RO concentrate along a second concentrate flow path from the RO membrane module to the second tank, the second tank serving as the receiver tank.

20. The method according to claim 19, wherein in the first cycle, the first feed flow path and the first concentrate flow path do not converge upstream of the inlet and downstream of the second tank, and wherein in the second cycle, the second feed flow path and the second concentrate flow path do not converge upstream of the inlet and downstream of the first tank.

21. The method according to claim 19 or claim 20, further comprising: for one intake of fresh feed, performing all of the at least two cycles.

22. The method according to claim 19 or claim 21, further comprising: controllably setting a target pressure at which the feed is delivered to the RO membrane module such that the target pressure is at least minimally greater than an osmotic pressure of the RO concentrate out of the RO membrane module in a current cycle.

23. The method according to claim 22, further comprising: progressively increasing the target pressure over the successive cycles.

24. The method according to any one of claims 19 to 23, further comprising: chemically treating respective contents of one or both of the feed tank and the receiver tank.

25. The method according to any one of claims 19 to 24, further comprising: passing the RO concentrate through a secondary membrane module, wherein the secondary membrane module is configured to filter impurities out from the RO concentrate.