CLAIMS

1. A wastewater treatment system comprising:

a source of wastewater to be treated;

a biological treatment train fluidly connected to the source of wastewater to be treated, the first treatment train comprising at least one biological reactor selected from the group consisting of an anaerobic reactor, an anoxic reactor, and an aerobic reactor;

a sludge thickener having a sludge-lean outlet, a thickened sludge outlet, and a thickener inlet fluidly connected downstream from a solids-rich sludge outlet of the at least one biological reactor;

an anaerobic digester fluidly connected downstream from the thickened sludge outlet of the sludge thickener; and

a digested anaerobic sludge recycle line fluidly connecting a digested sludge outlet of the anaerobic digester and an inlet of the at least one biological reactor.

2. The wastewater treatment system of claim 1, further comprising a separator having an inlet fluidly connected downstream from the at least one biological reactor, and a solids-rich outlet fluidly connected upstream of an inlet of the anaerobic digester.

3. The wastewater treatment system of claim 1, wherein the at least one biological reactor comprises at least one sequencing batch reactor having a basin with a basin inlet fluidly connectable to the source of the wastewater, an aeration system, a sludge collection system with a sludge outlet, and a decanting system with a supernatant outlet, and wherein the wastewater treatment system further comprises a controller configured to generate a first output signal that promotes fluid communication between the basin inlet and the source of wastewater, and a second output signal that promotes fluid communication between the solids-rich sludge outlet and the digester inlet.

4. The wastewater treatment system of claim 1, wherein the biological treatment train comprises:

a biological sorption tank having a sorption tank inlet fluidly connected to the source of the wastewater;

a separator fluidly having a separator inlet fluidly connected downstream from the biological sorption tank, a solids-rich sludge outlet, and a solids-lean outlet; and

an aerobic treatment tank having an aerobic tank inlet fluidly connected downstream from the solids-rich sludge outlet, and an at least partially aerobically treated sludge outlet fluidly connected to the sorption tank inlet.

5. The wastewater treatment system of any one of claims 1-4, further comprising a primary separator having a primary separator inlet fluidly connected to the source of wastewater to be treated, and a solids-lean wastewater outlet fluidly connected upstream of at least one biological reactor.

6. The wastewater treatment system of claim 5, wherein the primary separator further comprises a solids-rich wastewater outlet fluidly connected upstream of an inlet of the anaerobic digester.

7. The wastewater treatment system of any one of claims 1-6, further comprising:

an aerobic polishing unit fluidly connected downstream from the solids-lean outlet of the separator; and

a mixed liquor recycle line fluidly connecting an outlet of the aerobic polishing unit and the sorption tank inlet.

8. The wastewater treatment system of any one of claims 1-6, further comprising a membrane bioreactor fluidly connected downstream from the separator.

9. The wastewater treatment system of claim 3, wherein the controller is further configured to generate a third output signal that activates the aeration system, a fourth output signal that promotes quiescent conditions in the sequencing batch reactor after activation of the aeration system, a fifth output signal that activates the decanting system

after generating the fourth output signal, and a sixth output signal that activates the aeration system after generating the fifth output signal.

10. The wastewater treatment system of any one of claims 3 and 9, further comprising a membrane bioreactor fluidly connectable downstream from the supernatant outlet.

11. The wastewater treatment system of any one of claims 3 and 9, further comprising an aerobic polishing unit fluidly connectable downstream from the supernatant outlet.

12. The wastewater treatment system of any one of claims 3 and 9, further comprising a primary separator having a separator inlet fluidly connected to the source of wastewater, and a solids-lean wastewater outlet fluidly connectable to the basin inlet.

13. The wastewater treatment system of claim 12, wherein the primary separator further comprises a solids-rich wastewater outlet fluidly connectable to the anaerobic digester inlet.

14. A process for treating wastewater comprising:

providing a wastewater to be treated;

promoting biological sorption of the wastewater to be treated to produce a first mixed liquor;

producing a solids-rich sludge and a solids-lean portion from the first mixed liquor;

thickening at least a portion of the solids-rich sludge to produce a thickened sludge and a sludge-lean portion;

aerobically treating a portion of the solids-rich sludge to produce an at least partially aerobically treated sludge;

anaerobically digesting a portion of the thickened sludge to produce an anaerobically digested sludge;

combining at least a portion of the at least partially aerobically treated sludge with the wastewater to be treated; and

combining at least a portion of the anaerobically digested sludge with the wastewater to be treated.

15. The process of claim 14, further comprising combining at least a portion of the sludge-lean portion with the wastewater to be treated.

16. The process of any one of claims 14 and 15, further comprising aerobically treating at least a portion of the solids-lean portion to produce a treated product and a second mixed liquor.

17. The process of claim 16, further comprising combining at least a portion of the second mixed liquor with the wastewater to be treated.

18. The process of any one of claims 14-17, further comprising aerobically treating at least a portion of the anaerobically digested sludge with the portion of the solids-rich sludge to produce the at least partially aerobically treated sludge.

19. The process of claim 14, further comprising producing a solids-rich wastewater and a solids-lean wastewater from the wastewater to be treated, and wherein promoting biological sorption of at least a portion of the wastewater to be treated comprises promoting biological sorption of the solids-lean wastewater to produce the first mixed liquor.

20. The process of any one of claims 14-19, further comprising introducing the solids-lean portion into a membrane bioreactor.

21. The process of any one of claims 14-18, and 20, further comprising:

separating the wastewater to be treated into a solids-lean wastewater and a solids-rich wastewater;

promoting biological sorption of the solids-lean wastewater to produce at least a portion of the first mixed liquor; and

anaerobically digesting the solids-rich wastewater with the portion of the thickened sludge to produce the anaerobically digested sludge and an off-gas comprising methane.

22. The process of any one of claims 14-21, wherein anaerobically digesting a portion of the thickened sludge comprises collecting an off-gas comprising methane.

CLAIMS

1. A process for treating wastewater comprising:

providing a wastewater to be treated;

promoting biological sorption of the wastewater to be treated in a biological sorption tank to produce a first mixed liquor;

producing a solids-rich sludge and a solids-lean portion from the mixed liquor;

aerobically treating a first portion of the solids-rich sludge to produce an at least partially aerobically treated sludge;

anaerobically digesting a second portion of the solids-rich sludge to produce an anaerobically digested sludge;

combining at least a portion of the at least partially aerobically treated sludge with the wastewater to be treated; and

combining at least a portion of the anaerobically digested sludge with the wastewater to be treated.

2. The process of claim 1, further comprising:

thickening the solids-rich sludge to produce a thickened sludge and a sludge-lean portion; and

combining at least a portion of the sludge-lean portion with the wastewater to be treated,

wherein anaerobically digesting the second portion of the solids-rich sludge comprises anaerobically digesting the thickened sludge to produce at least a portion of the anaerobically digested sludge.

3. The process of claim 1, further comprising aerobically treating at least a portion of the solids-lean portion to produce a treated product and a second mixed liquor.

4. The process of claim 3, further comprising combining at least a portion of the second mixed liquor with the wastewater to be treated.

5. The process of claim 1, further comprising aerobically treating at least a portion of the anaerobically digested sludge with the first portion of the solids-rich sludge to produce

the at least partially aerobically treated sludge.

6. The process of claim 1, further comprising producing a solids-rich wastewater and a solids-lean wastewater from the wastewater to be treated, and wherein promoting biological sorption of at least a portion of the wastewater to be treated comprises promoting biological sorption of the solids-lean wastewater to produce the first mixed liquor.

7. The process of claim 1, further comprising introducing the solids-lean portion into a membrane bioreactor.

8. The process of claim 1, further comprising:

separating the wastewater to be treated into a solids-lean wastewater and a solids-rich wastewater;

promoting biological sorption of the solids-lean wastewater to produce at least a portion of the first mixed liquor; and

anaerobically digesting the solids-rich wastewater with the second portion of the solids-rich sludge to produce the anaerobically digested sludge and an off-gas comprising methane.

9. A process for treating wastewater comprising:

providing a wastewater stream to be treated;

introducing the wastewater stream into a biological sorption tank to produce a first mixed liquor stream;

introducing the mixed liquor stream into a separator to produce a solids-rich stream and a solids-lean stream;

introducing at least a portion of the solids-rich stream into an aerobic treating tank to produce an at least partially aerobically treated sludge stream;

introducing at least a portion of the solids-rich stream into an anaerobic digester to produce an anaerobically digested sludge stream;

introducing at least a portion of the at least partially aerobically treated sludge stream into the biological sorption tank; and

introducing at least a portion of the anaerobically digested sludge stream into the biological sorption tank.

10. The process of claim 9, further comprising introducing at least a portion of the solids-rich stream into a sludge thickener to produce a thickened sludge stream and a sludge-lean stream.

11. The process of claim 10, wherein introducing at least a portion of the solids-rich stream into an anaerobic digester comprises introducing the thickened sludge stream into the anaerobic digester to produce the anaerobically digested sludge stream.

12. The process of claim 9, wherein introducing the wastewater stream into the biological sorption tank comprises introducing the wastewater stream to be treated into a primary separator to produce a solids-rich wastewater stream and a solids-lean wastewater stream, and introducing the solids-lean wastewater stream into the biological sorption tank to produce the first mixed liquor stream.

13. The process of claim 12, further comprising introducing the solids-rich wastewater stream into the anaerobic digester to produce at least a portion of the anaerobically digested sludge stream.

14. The process of claim 13, further comprising introducing at least a portion of the anaerobically digested sludge stream into the aerobic treating tank to produce at least a portion of the at least partially aerobically treated sludge stream.

15. The process of claim 9, further comprising introducing the solids-lean stream from the separator into a membrane bioreactor.

16. The process of claim 9, further comprising:

introducing at least a portion of the solids-lean stream into an aerobic polishing system to produce a treated stream and a second mixed liquor stream; and

introducing at least a portion of the second mixed liquor stream into the biological sorption tank.

17. The process of claim 9, further comprising collecting an off-gas from the anaerobic

digester, the off-gas comprising methane.

18. A wastewater treatment system comprising:

a source of a wastewater to be treated;

a biological sorption tank having a sorption tank inlet fluidly connected to the source of the wastewater;

a separator fluidly having a separator inlet fluidly connected downstream from the biological sorption tank, a sludge outlet, and a solids-lean outlet;

an aerobic treatment tank having an aerobic tank inlet fluidly connected downstream from the sludge outlet, and an at least partially aerobically treated sludge outlet fluidly connected to the sorption tank inlet; and

an anaerobic digester having a digester inlet fluidly connected downstream from the sludge outlet, and a digested sludge outlet fluidly connected upstream of the sorption tank inlet.

19. The wastewater treatment system of claim 18, further comprising a sludge thickener having a thickener inlet fluidly connected downstream from the sludge outlet, a thickened sludge outlet fluidly connected upstream of the digester inlet, and a sludge-lean outlet fluidly connected upstream of the sorption tank inlet.

20. The wastewater treatment system of claim 18, wherein the anaerobic digester is fluidly connected upstream of the sorption tank inlet through the aerobic treatment tank.

21. The wastewater treatment system of claim 18, further comprising a primary separator having a primary separator inlet fluidly connected to the source of wastewater to be treated, a solids-lean wastewater outlet fluidly connected upstream of the sorption tank inlet.

22. The wastewater treatment system of claim 21, wherein the primary separator further comprises a solids-rich wastewater outlet fluidly connected upstream of the digester inlet.

23. The wastewater treatment system of claim 18, further comprising an aerobic polishing unit fluidly connected downstream from the solids-lean outlet of the separator.

24. The wastewater treatment system of claim 23, further comprising a mixed liquor recycle line fluidly connecting an outlet of the aerobic polishing unit and the sorption tank inlet.

25. The wastewater treatment system of claim 18, further comprising a membrane bioreactor fluidly connected downstream from the separator.

26. A wastewater treatment system comprising:

a source of wastewater to be treated;

a sequencing batch reactor having a basin with a basin inlet fluidly connectable to the source of the wastewater, an aeration system, a sludge collection system with a sludge outlet, and a decanting system with a supernatant outlet;

an anaerobic digester having a digester inlet fluidly connectable downstream from the sludge outlet, and a digested sludge outlet fluidly connectable to the basin inlet;

a sludge thickener fluidly connectable downstream from the sludge outlet, the sludge thickener having a thickened sludge outlet fluidly connectable to the digester inlet and configured to direct all of a thickened sludge produced in the sludge thickener into the digester inlet, and a sludge-lean outlet fluidly connectable upstream of the basin inlet; and

a controller configured to generate a first output signal that provides fluid communication between the basin inlet and the source of wastewater, and a second signal that provides fluid communication between the sludge outlet and the digester inlet.

27. The wastewater treatment system of claim 26, wherein the controller is further configured to generate a third output signal that activates the aeration system.

28. The wastewater treatment system of claim 27, wherein the controller is further configured to generate a fourth output signal that promotes quiescent conditions in the sequencing batch reactor after activation of the aeration system.

29. The wastewater treatment system of claim 28, wherein the controller is further configured to generate a fifth output signal that activates the decanting system after generating the fourth output signal.

30. The wastewater treatment system of claim 29, wherein the controller is further configured to generate a sixth output signal that activates the aeration system after generating the fifth output signal.

31. The wastewater treatment system of claim 26, further comprising a membrane bioreactor fluidly connectable downstream from the supernatant outlet.

32. The wastewater treatment system of claim 26, further comprising an aerobic polishing unit fluidly connectable downstream from the supernatant outlet.

33. The wastewater treatment system of claim 26, further comprising a primary separator having a separator inlet fluidly connected to the source of wastewater, and a solids-lean wastewater outlet fluidly connectable to the basin inlet.

34. The wastewater treatment system of claim 33, wherein the primary separator further comprises a solids-rich wastewater outlet fluidly connectable to the digester inlet.

35. A wastewater treatment system comprising:

a source of wastewater to be treated;

a biological treatment train fluidly connected to the source of wastewater to be treated, the first treatment train comprising at least one biological reactor selected from the group consisting of an anaerobic reactor, an anoxic reactor, and an aerobic reactor;

a separator having an inlet fluidly connected downstream from the at least one biological reactor, a solids-rich outlet fluidly connected upstream of an inlet of an anaerobic digester and configured to direct all of a thickened sludge produced in the separator into the inlet of the anaerobic digester, and a solids-lean outlet fluidly connected upstream of an inlet of the at least one biological reactor; and

a digested anaerobic sludge recycle line fluidly connecting a digested sludge outlet of the anaerobic digester and an inlet of the at least one biological reactor.

36. The wastewater treatment system of claim 35, wherein the at least one biological reactor comprises at least one sequencing batch reactor.

37. The wastewater treatment system of claim 35, further comprising a primary separator having a separator inlet fluidly connected to the source of wastewater and a solids-lean wastewater outlet fluidly connectable to the basin inlet.

38. A method of facilitating wastewater treatment in a wastewater treatment system having a biological treatment train with at least one biological reactor selected from the group consisting of an anaerobic reactor, an anoxic reactor, and an aerobic reactor, the method comprising:

fluidly connecting a solids-rich outlet of the biological treatment train upstream of an inlet of a separator;

fluidly connecting a solids-rich outlet of the separator directly to an inlet of a sludge thickener;

fluidly connecting a solids-rich outlet of the sludge thickener directly to an inlet of an anaerobic digester, the solids-rich outlet of the sludge thickener configured to direct all of a thickened sludge produced in the sludge thickener into the inlet of the anaerobic digester;

fluidly connecting a solids-lean outlet of the separator upstream of an inlet of the at least one biological reactor; and

fluidly connecting a digested sludge outlet of the anaerobic digester upstream of an inlet of the at least one biological reactor.

39. The method of claim 38, wherein the at least one biological reactor comprises a sequencing batch reactor.

40. The method of claim 38, further comprising fluidly connecting an outlet of a primary clarifier upstream of an inlet of the at least one biological reactor.