Claims:

1. A method for treating wastewater comprising:

mixing wastewater with adsorbent material in a mixing zone for a time sufficient for adsorption of contaminants from the wastewater onto the adsorbent material;

separating and removing a major portion of the wastewater from the mixture of wastewater and adsorbent material;

passing the adsorbent material having contaminants adsorbed thereon and a minor portion of the wastewater to a biological regeneration reactor;

retaining the adsorbent material and wastewater in suspension in the biological regeneration reactor for a period of time that is sufficient to allow microorganisms in the biological regeneration reactor to biologically act on at least a portion of the adsorbed contaminants;

discharging biologically treated water effluent from the biological regeneration reactor; and

recycling regenerated adsorbent material to the mixing zone.

2. The method of claim 1, wherein the wastewater comprises low concentration wastewater that is an effluent subjected to an upstream wastewater treatment process.

3. The method of claim 1, wherein the wastewater is a low concentration wastewater that has a concentration of contaminants that is lower than an influent feed concentration that is required to support biological activity in a conventional biological reactor.

4. The method of claim 1, further comprising removing solids from the biological regeneration reactor water effluent.

5. The method of claim 4, wherein the solids are removed using a membrane operating system.

6. The method of claim 4, wherein the solids are removed using a clarifier and/or a settler.

7. The method of claim 1, which further comprises shearing any accumulated biomass from the adsorbent material prior to recycling to the mixing zone.

8. The method of claim 7, further comprising separating the biomass from the adsorbent material prior to recycling the adsorbent material to the mixing zone.

9. A system for treatment of wastewater comprising:

a mixing zone including

a wastewater inlet,

an adsorbent material inlet and

a discharge outlet;

an adsorbent material settling and liquid separation zone including

a slurry inlet in communication with the discharge outlet of the mixing zone,

a treated water outlet, and

a contaminated adsorbent material outlet;

an adsorbent material biological regeneration reactor system including

a biological regeneration reactor including a contaminated adsorbent material inlet in communication with the contaminated adsorbent material outlet of the adsorbent material settling and liquid separation zone,

a biologically treated water outlet, and

a regenerated adsorbent material outlet in communication with the adsorbent material inlet of the mixing zone.

10. The system of claim 9, further comprising a solids separation apparatus in communication with the biologically treated water outlet.

11. The system of claim 10, wherein the solids separation apparatus is a membrane operating system.

12. The system of claim 10, wherein the solids separation apparatus is a clarifier and/or a settler.

13. The system of claim 9, further comprising a shearing zone including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

14. The system of claim 13, further comprising an adsorbent material/biomass separation zone including an inlet in communication with the outlet of the shearing zone and an outlet in communication with the adsorbent material inlet of the mixing zone.

15. The system of claim 9, further comprising an apparatus for shearing and separating biomass from adsorbent material including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

16. The system of claim 9, wherein the biological regeneration reactor is constructed and arranged for shearing and separating biomass from adsorbent material.

17. The system of claim 9, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet.

18. A wastewater treatment system comprising:

a high flux adsorption system including

an inlet for receiving wastewater,

a source of adsorbent material for contacting the wastewater and adsorbing contaminants from the wastewater,

a liquid outlet for discharging a major portion of the received wastewater that has been contacted by the adsorbent material, and

an adsorbent material outlet for discharging adsorbent material having adsorbed contaminants and a minor portion of the received wastewater; and

a low flux adsorbent material biological regeneration reactor system for maintaining the adsorbent material having adsorbed contaminants in suspension for a period of time that is sufficient to allow microorganisms to digest adsorbed organic contaminants, the low flux adsorbent material biological regeneration reactor system including

a biological regeneration reactor having

an inlet for receiving adsorbent material with adsorbed contaminants from the adsorbent material outlet of the high flux adsorption system,

a mixed liquor outlet, and

an adsorbent material outlet in communication with the source of adsorbent material of the high flux adsorption system.

19. The system of claim 18 in which the low flux adsorbent material biological regeneration reactor system further comprises:

a shearing apparatus for shearing excess accumulated biomass from adsorbent material, the shearing apparatus being positioned within the biological regeneration reactor and/or separate from the biological regeneration reactor and connected to the adsorbent material outlet for receiving adsorbent material from the biological regeneration reactor;

an adsorbent material/biomass separation zone for separating free biomass from a mixture of adsorbent material and free biomass;

an adsorbent material conduit for passing separated adsorbent material from the adsorbent material/biomass separation zone to the high flux adsorption system; and

a biomass conduit for passing separated biomass from the adsorbent material/biomass separation zone to the biological regeneration reactor or a location downstream of the biological regeneration reactor.

20. The system of claim 18 in which the low flux adsorbent material biological regeneration reactor system further comprises:

a combined apparatus for shearing and separating accumulated biomass from adsorbent material being positioned within the biological regeneration reactor and/or separate from the biological regeneration reactor and connected to the adsorbent material outlet for receiving adsorbent material from the biological regeneration reactor, and having an outlet for discharging separated adsorbent material and an outlet for discharging free biomass;

an adsorbent material conduit in communication with the adsorbent material outlet of the combined apparatus for returning adsorbent material to the high flux adsorption system; and

a biomass conduit in communication with the biomass outlet of the combined apparatus for passing separated biomass to the biological regeneration reactor or a location downstream of the biological regeneration reactor.

21. The system of claim 18, wherein the low flux adsorbent material biological regeneration reactor system further comprises a membrane operating system in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

22. The system of claim 18, wherein the low flux adsorbent material biological regeneration reactor system further comprises a clarifier and/or a settler in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

23. The system of claim 18, wherein the high flux adsorption system includes a mixing zone and a settling zone.

24. The system of claim 18, wherein the high flux adsorption system includes an adsorbent material filtration apparatus.

25. The system of claim 18, wherein the high flux adsorption system includes a continuous backwash filter.

26. The system of claim 18, wherein the high flux adsorption system includes a continuous regenerating filtration system or a continuous regenerating walnut shell filter.

27. The system of claim 18, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet.

28. The system of claim 18, further comprising

a sensor constructed and arranged to measure a parameter of the system; and

a controller in electronic communication with the sensor programmed to instruct performance of an act based on the measured parameter of the system.

29. The wastewater treatment system of claim 28, wherein the measured parameter is the concentration of one or more predetermined compounds.

30. The wastewater treatment system of claim 28, wherein the act comprises removing at least a portion of the adsorbent material from the biological regeneration reactor.

31. The wastewater treatment system of claim 28, wherein the act comprise adding adsorbent material to the biological regeneration reactor.

CLAIMS

1. (Currently Amended) A method for treating wastewater comprising:

mixing wastewater comprising contaminants with adsorbent material in a mixing zone for a time sufficient for adsorption of the contaminants from the wastewater onto the adsorbent material to produce a mixture of treated wastewater and adsorbent material having contaminants adsorbed thereon;

separating and removing a major portion of the treated wastewater from the mixture of treated wastewater and adsorbent material having contaminants adsorbed thereon;

passing the adsorbent material having contaminants adsorbed thereon and a minor portion of the treated wastewater to a biological regeneration reactor containing microorganisms;

retaining the adsorbent material having contaminants adsorbed thereon and the minor portion of the treated wastewater in suspension in the biological regeneration reactor for a period of time that is sufficient to allow the microorganisms in the biological regeneration reactor to biologically act on at least a portion of the ~~adsorbed~~ contaminants on the adsorbent material to produce a regenerated adsorbent material and a biologically treated water effluent;

discharging the biologically treated water effluent from the biological regeneration reactor; and

recycling the regenerated adsorbent material to the mixing zone.

2. (Currently Amended) The method of claim 1, wherein the wastewater comprises a low concentration wastewater that is an effluent ~~subjected to~~ of an upstream wastewater treatment process.

3. (Original) The method of claim 1, wherein the wastewater is a low concentration wastewater that has a concentration of contaminants that is lower than an influent feed concentration that is required to support biological activity in a conventional biological reactor.

4. (Currently Amended) The method of claim 1, further comprising removing solids from the biologically treated ~~regeneration reactor~~ water effluent.

5. (Original) The method of claim 4, wherein the solids are removed using a membrane operating system.

6. (Currently Amended) The method of claim 4, wherein the solids are removed using at least one of a clarifier ~~and/or~~ and a settler.

7. (Currently Amended) The method of claim 1, ~~which~~ further ~~comprises~~ comprising shearing ~~any~~ an accumulated biomass from the regenerated adsorbent material prior to recycling the regenerated adsorbent material to the mixing zone.

8. (Currently Amended) The method of claim 7, further comprising separating the accumulated biomass from the regenerated adsorbent material prior to recycling the regenerated adsorbent material to the mixing zone.

9. (Currently Amended) A system for treatment of wastewater comprising:

a mixing zone including

a wastewater inlet,

an adsorbent material inlet, and

a discharge outlet;

an adsorbent material settling and liquid separation zone including

a slurry inlet in communication with the discharge outlet of the mixing zone,

a treated water outlet, and

a contaminated adsorbent material outlet; and

an adsorbent material biological regeneration reactor system including

a biological regeneration reactor including a contaminated adsorbent material inlet in communication with the contaminated adsorbent material outlet of the adsorbent material settling and liquid separation zone,

a biologically treated water outlet, and

a regenerated adsorbent material outlet in communication with the adsorbent material inlet of the mixing zone.

10. (Original) The system of claim 9, further comprising a solids separation apparatus in communication with the biologically treated water outlet.

11. (Original) The system of claim 10, wherein the solids separation apparatus is a membrane operating system.

12. (Currently Amended) The system of claim 10, wherein the solids separation apparatus is at least one of a clarifier ~~and/or~~ and a settler.

13. (Original) The system of claim 9, further comprising a shearing zone including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

14. (Original) The system of claim 13, further comprising an adsorbent material/biomass separation zone including an inlet in communication with the outlet of the shearing zone and an outlet in communication with the adsorbent material inlet of the mixing zone.

15. (Original) The system of claim 9, further comprising an apparatus for shearing and separating biomass from adsorbent material including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

16. (Currently Amended) The system of claim 9, wherein the biological regeneration reactor is constructed and arranged for shearing and separating a biomass from a regenerated adsorbent material.

17. (Currently Amended) The system of claim 9, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet fluidly connectable to the upstream wastewater treatment system.

18. (Currently Amended) A wastewater treatment system comprising:

a high flux adsorption system including

an inlet for receiving wastewater comprising contaminants,

a source of adsorbent material for contacting the wastewater and adsorbing the contaminants from the wastewater to produce an adsorbent material having contaminants adsorbed thereon and a treated wastewater,

a liquid outlet for discharging a major portion of the ~~received~~ treated wastewater ~~that has been contacted by the adsorbent material~~, and

an adsorbent material outlet for discharging the adsorbent material having ~~adsorbed~~ contaminants adsorbed thereon and a minor portion of the ~~received~~ treated wastewater; and

a low flux adsorbent material biological regeneration reactor system for maintaining the adsorbent material having ~~adsorbed~~ contaminants adsorbed thereon in suspension for a period of time that is sufficient to allow microorganisms to digest the contaminants adsorbed ~~organic contaminants~~ thereon, the low flux adsorbent material biological regeneration reactor system including

a biological regeneration reactor having

an inlet for receiving adsorbent material ~~with adsorbed~~ having contaminants adsorbed thereon from the adsorbent material outlet of the high flux adsorption system,

a mixed liquor outlet, and

an adsorbent material outlet in communication with the source of adsorbent material of the high flux adsorption system.

19. (Currently Amended) The system of claim 18 in which the low flux adsorbent material biological regeneration reactor system further comprises:

a shearing apparatus for shearing ~~excess~~ an accumulated biomass from adsorbent material to produce a mixture of a sheared adsorbent material and a free biomass, the shearing apparatus being positioned in at least one location selected from

within the biological regeneration reactor ~~and/or~~ and

separate from the biological regeneration reactor and connected to the adsorbent material outlet for receiving a regenerated adsorbent material from the biological regeneration reactor;

an adsorbent material/biomass separation zone for separating the free biomass from ~~a~~ the mixture of sheared adsorbent material and free biomass to produce a separated sheared adsorbent material and a free biomass;

an adsorbent material conduit for passing the separated sheared adsorbent material from the adsorbent material/biomass separation zone to the high flux adsorption system; and

a biomass conduit for passing ~~separated~~ free biomass from the adsorbent material/biomass separation zone to at least one of the biological regeneration reactor ~~or~~ and a location downstream of the biological regeneration reactor.

20. (Currently Amended) The system of claim 18 in which the low flux adsorbent material biological regeneration reactor system further comprises:

a combined apparatus for shearing and separating an accumulated biomass from a regenerated adsorbent material being positioned in at least one location selected from

within the biological regeneration reactor ~~and/or~~ and

separate from the biological regeneration reactor and connected to the regenerated adsorbent material outlet for receiving the regenerated adsorbent material from the biological regeneration reactor, and having an outlet for discharging a separated sheared adsorbent material and an outlet for discharging a free biomass;

an adsorbent material conduit in communication with the regenerated adsorbent material outlet of the combined apparatus for returning regenerated adsorbent material to the high flux adsorption system; and

a biomass conduit in communication with the outlet for discharging the free biomass ~~outlet~~ of the combined apparatus for passing ~~separated~~ free biomass to at least one of the biological regeneration reactor ~~or~~ and a location downstream of the biological regeneration reactor.

21. (Original) The system of claim 18, wherein the low flux adsorbent material biological regeneration reactor system further comprises a membrane operating system in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

22. (Currently Amended) The system of claim 18, wherein the low flux adsorbent material biological regeneration reactor system further comprises at least one of a clarifier

~~and/or~~ and a settler in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

23. (Original) The system of claim 18, wherein the high flux adsorption system includes a mixing zone and a settling zone.

24. (Original) The system of claim 18, wherein the high flux adsorption system includes an adsorbent material filtration apparatus.

25. (Original) The system of claim 18, wherein the high flux adsorption system includes a continuous backwash filter.

26. (Currently Amended) The system of claim 18, wherein the high flux adsorption system includes at least one of a continuous regenerating filtration system ~~or~~ and a continuous regenerating walnut shell filter.

27. (Currently Amended) The system of claim 18, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet fluidly connectable to the upstream wastewater treatment system.

28. (Currently Amended) The system of claim 18, further comprising

a sensor constructed and arranged to measure a parameter of the wastewater treatment system; and

a controller in electronic communication with the sensor programmed to instruct performance of an act based on the measured parameter of the system.

29. (Currently Amended) The wastewater treatment system of claim 28, wherein the measured parameter is the concentration of at least one ~~or more~~ predetermined ~~compounds~~ compound.

30. (Currently Amended) The wastewater treatment system of claim 28, wherein the act comprises removing at least a portion of at least one of the adsorbent material having contaminants adsorbed thereon and regenerated adsorbent material from the biological regeneration reactor.

31. (Currently Amended) The wastewater treatment system of claim 28, wherein the act ~~comprise~~ comprises adding adsorbent material to the biological regeneration reactor.

CLAIMS:

1. A method for treating wastewater comprising:

mixing wastewater comprising contaminants with adsorbent material in a mixing zone for a time sufficient for adsorption of the contaminants from the wastewater onto the adsorbent material to produce a mixture of treated wastewater and adsorbent material having contaminants adsorbed thereon;

separating and removing a major portion of the treated wastewater from the mixture of treated wastewater and adsorbent material having contaminants adsorbed thereon;

passing the adsorbent material having contaminants adsorbed thereon and a minor portion of the treated wastewater to a biological regeneration reactor containing microorganisms;

retaining the adsorbent material having contaminants adsorbed thereon and the minor portion of the treated wastewater in suspension in the biological regeneration reactor for a period of time that is sufficient to allow the microorganisms in the biological regeneration reactor to biologically act on at least a portion of the contaminants on the adsorbent material to produce a regenerated adsorbent material and a biologically treated water effluent;

discharging the biologically treated water effluent from the biological regeneration reactor; and

recycling the regenerated adsorbent material to the mixing zone.

2. The method of claim 1, wherein the wastewater comprises a low concentration wastewater that is an effluent of an upstream wastewater treatment process.

3. The method of claim 1, wherein the wastewater is a low concentration wastewater that has a concentration of contaminants that is lower than an influent feed concentration that is required to support biological activity in a conventional biological reactor.

4. The method of claim 1, further comprising removing solids from the biologically treated water effluent.

5. The method of claim 4, wherein the solids are removed using a membrane operating system.

6. The method of claim 4, wherein the solids are removed using at least one of a clarifier and a settler.

7. The method of claim 1, further comprising shearing an accumulated biomass from the regenerated adsorbent material prior to recycling the regenerated adsorbent material to the mixing zone.

8. The method of claim 7, further comprising separating the accumulated biomass from the regenerated adsorbent material prior to recycling the regenerated adsorbent material to the mixing zone.

9. A system for treatment of wastewater comprising:

a mixing zone including

a wastewater inlet,

an adsorbent material inlet, and

a discharge outlet;

an adsorbent material settling and liquid separation zone including

a slurry inlet in communication with the discharge outlet of the mixing zone,

a treated water outlet, and

a contaminated adsorbent material outlet; and

an adsorbent material biological regeneration reactor system including

a biological regeneration reactor including a contaminated adsorbent material inlet in communication with the contaminated adsorbent material outlet of the adsorbent material settling and liquid separation zone,

a biologically treated water outlet, and

a regenerated adsorbent material outlet in communication with the adsorbent material inlet of the mixing zone.

10. The system of claim 9, further comprising a solids separation apparatus in communication with the biologically treated water outlet.

11. The system of claim 10, wherein the solids separation apparatus is a membrane operating system.

12. The system of claim 10, wherein the solids separation apparatus is at least one of a clarifier and a settler.

13. The system of claim 9, further comprising a shearing zone including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

14. The system of claim 13, further comprising an adsorbent material/biomass separation zone including an inlet in communication with the outlet of the shearing zone and an outlet in communication with the adsorbent material inlet of the mixing zone.

15. The system of claim 9, further comprising an apparatus for shearing and separating biomass from adsorbent material including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

16. The system of claim 9, wherein the biological regeneration reactor is constructed and arranged for shearing and separating a biomass from a regenerated adsorbent material.

17. The system of claim 9, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet fluidly connectable to the upstream wastewater treatment system.

18. A wastewater treatment system comprising:

a high flux adsorption system including

an inlet for receiving wastewater comprising contaminants,

a source of adsorbent material for contacting the wastewater and adsorbing the contaminants from the wastewater to produce an adsorbent material having contaminants adsorbed thereon and a treated wastewater,

a liquid outlet for discharging a major portion of the treated wastewater, and

an adsorbent material outlet for discharging the adsorbent material having contaminants adsorbed thereon and a minor portion of the treated wastewater; and

a low flux adsorbent material biological regeneration reactor system for maintaining the adsorbent material having contaminants adsorbed thereon in suspension for a period of time that is sufficient to allow microorganisms to digest the contaminants adsorbed thereon, the low flux adsorbent material biological regeneration reactor system including

a biological regeneration reactor having

an inlet for receiving adsorbent material having contaminants adsorbed thereon from the adsorbent material outlet of the high flux adsorption system,

a mixed liquor outlet, and

an adsorbent material outlet in communication with the source of adsorbent material of the high flux adsorption system.

19. The system of claim 18 in which the low flux adsorbent material biological regeneration reactor system further comprises:

a shearing apparatus for shearing an accumulated biomass from adsorbent material to produce a mixture of a sheared adsorbent material and a free biomass, the shearing apparatus being positioned in at least one location selected from

within the biological regeneration reactor and

separate from the biological regeneration reactor and connected to the adsorbent material outlet for receiving a regenerated adsorbent material from the biological regeneration reactor;

an adsorbent material/biomass separation zone for separating the free biomass from the mixture of sheared adsorbent material and free biomass to produce a separated sheared adsorbent material and a free biomass;

an adsorbent material conduit for passing the separated sheared adsorbent material from the adsorbent material/biomass separation zone to the high flux adsorption system; and

a biomass conduit for passing free biomass from the adsorbent material/biomass separation zone to at least one of the biological regeneration reactor and a location downstream of the biological regeneration reactor.

20. The system of claim 18 in which the low flux adsorbent material biological regeneration reactor system further comprises:

a combined apparatus for shearing and separating an accumulated biomass from a regenerated adsorbent material being positioned in at least one location selected from

within the biological regeneration reactor and

separate from the biological regeneration reactor and connected to the regenerated adsorbent material outlet for receiving the regenerated adsorbent material from the biological regeneration reactor, and having an outlet for discharging a separated sheared adsorbent material and an outlet for discharging a free biomass;

an adsorbent material conduit in communication with the regenerated adsorbent material outlet of the combined apparatus for returning regenerated adsorbent material to the high flux adsorption system; and

a biomass conduit in communication with the outlet for discharging the free biomass of the combined apparatus for passing free biomass to at least one of the biological regeneration reactor and a location downstream of the biological regeneration reactor.

21. The system of claim 18, wherein the low flux adsorbent material biological regeneration reactor system further comprises a membrane operating system in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

22. The system of claim 18, wherein the low flux adsorbent material biological regeneration reactor system further comprises at least one of a clarifier and a settler in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

23. The system of claim 18, wherein the high flux adsorption system includes a mixing zone and a settling zone.

24. The system of claim 18, wherein the high flux adsorption system includes an adsorbent material filtration apparatus.

25. The system of claim 18, wherein the high flux adsorption system includes a continuous backwash filter.

26. The system of claim 18, wherein the high flux adsorption system includes at least one of a continuous regenerating filtration system and a continuous regenerating walnut shell filter.

27. The system of claim 18, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the

mixing zone is a low concentration wastewater inlet fluidly connectable to the upstream wastewater treatment system.

28. The system of claim 18, further comprising

a sensor constructed and arranged to measure a parameter of the wastewater treatment system; and

a controller in electronic communication with the sensor programmed to instruct performance of an act based on the measured parameter of the system.

29. The wastewater treatment system of claim 28, wherein the measured parameter is the concentration of at least one predetermined compound.

30. The wastewater treatment system of claim 28, wherein the act comprises removing at least a portion of at least one of the adsorbent material having contaminants adsorbed thereon and regenerated adsorbent material from the biological regeneration reactor.

31. The wastewater treatment system of claim 28, wherein the act comprises adding adsorbent material to the biological regeneration reactor.

32. A method for treating wastewater comprising:

mixing wastewater comprising biologically refractory and/or bio-inhibitory compounds with adsorbent material in a mixing zone for a time sufficient for adsorption of the biologically refractory and/or bio-inhibitory compounds from the wastewater onto the adsorbent material to produce a mixture of adsorbent-treated wastewater and adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon, wherein the adsorbent material is characterized by adsorptive capacity for adsorption of biologically refractory compounds and/or biologically inhibitory compounds, and capacity for microorganisms adhered to the adsorbent material, wherein the combined adsorbent material characteristics contribute to biological regeneration of the adsorbent material;

separating and removing a major portion of the adsorbent-treated wastewater from the mixture of adsorbent-treated wastewater and adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon;

passing the adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon and a minor portion of the adsorbent-treated wastewater to a biological regeneration reactor containing microorganisms;

retaining the adsorbent material having contaminants adsorbed thereon and the minor portion of the treated wastewater in suspension in the biological regeneration reactor for a period of time that is sufficient to allow the microorganisms in the biological regeneration reactor to biologically act on at least a portion of the biologically refractory and/or bio-inhibitory compounds on the adsorbent material to produce biologically regenerated adsorbent material and a biologically treated water effluent;

discharging the biologically treated water effluent from the biological regeneration reactor; and

recycling the biologically regenerated adsorbent material to the mixing zone.

33. The method of claim 32, wherein the adsorbent material is selected from the group consisting of granular activated carbon, granular iron-based compounds, granular manganese-based compounds, granular alumino-silicate composites, synthetic resins, and combinations including at least one of the foregoing adsorbent materials.

34. The method as in claim 32, wherein the adsorbent material comprises granular activated carbon.

35. The method as in claim 34, wherein the granular activated carbon is treated to provide affinity to predetermined chemical species, metals or other compounds found to be present in the influent wastewater.

36. The method as in claim 34, wherein the adsorbent material further includes one or more of additional adsorbent materials selected from the group consisting of granular iron-based compounds, granular manganese-based compounds, granular alumino-silicate composites and synthetic resins.

37. The method of claim 32, wherein the wastewater comprises a low concentration wastewater that is an effluent of an upstream wastewater treatment process.

38. The method of claim 32, wherein the wastewater is a low concentration wastewater that has a concentration of contaminants that is lower than an influent feed concentration that is required to support biological activity in a conventional biological reactor.

39. The method of claim 32, further comprising removing solids from the biologically treated water effluent.

40. The method of claim 39, wherein the solids are removed using a membrane operating system.

41. The method of claim 39, wherein the solids are removed using at least one of a clarifier and a settler.

42. The method of claim 39, further comprising passing at least a portion of activated sludge from the solids separation apparatus to the biological regeneration reactor.

43. The method of claim 39, wherein the biological regeneration reactor water effluent is passed through a separation subsystem in the biological regeneration reactor or downstream of the biological regeneration reactor to introduce the biological regeneration reactor water effluent that is substantially free of adsorbent material to the solids separation apparatus.

44. The method of claim 43, wherein the adsorbent material has an effective granule size of at least about 0.3 millimeters.

45. The method of claim 43, wherein the adsorbent material has an effective granule size of at least about 0.5 millimeters.

46. The method of claim 32, further comprising shearing an accumulated biomass from the regenerated adsorbent material prior to recycling the regenerated adsorbent material to the mixing zone.

47. The method of claim 46, further comprising separating the accumulated biomass from the regenerated adsorbent material prior to recycling the regenerated adsorbent material to the mixing zone.

48. A system for treatment of wastewater comprising:

a source of fresh or recycled porous adsorbent material, wherein the adsorbent material is characterized by adsorptive capacity for adsorption of biologically refractory compounds and/or biologically inhibitory compounds, and capacity for microorganisms adhered to the adsorbent material, wherein the combined adsorbent material characteristics contribute to biological regeneration of the adsorbent material;

a mixing zone including

a wastewater inlet,

an adsorbent material inlet, and

a discharge outlet;

an adsorbent material settling and liquid separation zone including

a slurry inlet in communication with the discharge outlet of the mixing zone,

an adsorbent-treated water outlet, and

a contaminated adsorbent material outlet; and

an adsorbent material biological regeneration reactor system including

a biological regeneration reactor including a contaminated adsorbent material inlet in communication with the contaminated adsorbent material outlet of the adsorbent material settling and liquid separation zone,

a biologically treated water outlet, and

a regenerated adsorbent material outlet in communication with the adsorbent material inlet of the mixing zone.

49. The system of claim 48, wherein the adsorbent material is selected from the group consisting of granular activated carbon, granular iron-based compounds, granular manganese-based compounds, granular alumino-silicate composites, synthetic resins, and combinations including at least one of the foregoing adsorbent materials.

50. The system of claim 48, wherein the adsorbent material comprises granular activated carbon.

51. The system of in claim 50, wherein the granular activated carbon is treated to provide affinity to predetermined chemical species, metals or other compounds found to be present in the influent wastewater.

51. The system of claim 50, wherein the adsorbent material further includes one or more of additional adsorbent materials selected from the group consisting of granular iron-based compounds, granular manganese-based compounds, granular alumino-silicate composites and synthetic resins.

52. The system of claim 48, further comprising a solids separation apparatus in communication with the biologically treated water outlet.

53. The system of claim 52, wherein the solids separation apparatus is a membrane operating system.

54. The system of claim 52, wherein the solids separation apparatus is at least one of a clarifier and a settler.

55. The system of claim 52, further comprising a return activated sludge line for returning at least a portion of activated sludge from the solids separation apparatus to the biological regeneration reactor.

56. The system of claim 52, further comprising a separation subsystem that is

in the biological regeneration reactor or

downstream of the biological regeneration reactor and between the biological regeneration reactor and the solids separation apparatus,

the separation subsystem constructed and arranged to introduce the biological regeneration reactor water effluent that is substantially free of adsorbent material to the solids separation apparatus.

57. The system of claim 56, wherein the adsorbent material has an effective granule size of at least about 0.3 millimeters.

58. The system of claim 56, wherein the adsorbent material has an effective granule size of at least about 0.5 millimeters.

59. The system of claim 48, further comprising a shearing zone including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

60. The system of claim 59, further comprising an adsorbent material/biomass separation zone including an inlet in communication with the outlet of the shearing zone and an outlet in communication with the adsorbent material inlet of the mixing zone.

61. The system of claim 48, further comprising an apparatus for shearing and separating biomass from adsorbent material including an inlet in communication with the regenerated adsorbent material outlet and an outlet in communication with the adsorbent material inlet of the mixing zone.

62. The system of claim 48, wherein the biological regeneration reactor is constructed and arranged for shearing and separating a biomass from a regenerated adsorbent material.

63. The system of claim 48, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet fluidly connectable to the upstream wastewater treatment system.

64. The system of claim 48, wherein the adsorbent material settling and liquid separation zone includes a vessel configured with an inverse conical or frusto-conical bottom portion, the contaminated adsorbent material outlet positioned in said inverse conical or frusto-conical bottom portion.

65. The system of claim 48, wherein the adsorbent material settling and liquid separation zone includes an apparatus selected from the group consisting of a centrifuge, a hydrocyclone, and a clarifier.

66. The system of claim 48, wherein the mixing zone, and the adsorbent material settling and liquid separation zone, are provided as an integrated mixing/settling unit operation.

67. The system of claim 66, wherein the integrated mixing/settling unit operation is a continuous backwash filter or a continuous regenerating filtration system.

68. A wastewater treatment system comprising:

a high flux adsorption system including

an inlet for receiving wastewater comprising biologically refractory and/or bio-inhibitory compounds,

a source of fresh or recycled porous adsorbent material, wherein the adsorbent material is characterized by adsorptive capacity for adsorption of biologically refractory compounds and/or biologically inhibitory compounds, and capacity for microorganisms adhered to the adsorbent material, wherein the combined adsorbent material characteristics contribute to biological regeneration of the adsorbent material, the adsorbent material for contacting the wastewater and adsorbing the biologically

refractory and/or bio-inhibitory compounds from the wastewater to produce an adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon and a treated wastewater,

a liquid outlet for discharging a major portion of the treated wastewater, and

an adsorbent material outlet for discharging the adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon and a minor portion of the treated wastewater; and

a low flux adsorbent material biological regeneration reactor system for maintaining the adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon in suspension for a period of time that is sufficient to allow microorganisms to digest the biologically refractory and/or bio-inhibitory compounds adsorbed thereon, the low flux adsorbent material biological regeneration reactor system including

a biological regeneration reactor having

an inlet for receiving adsorbent material having biologically refractory and/or bio-inhibitory compounds adsorbed thereon from the adsorbent material outlet of the high flux adsorption system,

a mixed liquor outlet, and

an adsorbent material outlet in communication with the source of adsorbent material of the high flux adsorption system.

69. The system of claim 68, wherein the adsorbent material is selected from the group consisting of granular activated carbon, granular iron-based compounds, granular manganese-based compounds, granular alumino-silicate composites, synthetic resins, and combinations including at least one of the foregoing adsorbent materials.

70. The system of claim 68, wherein the adsorbent material comprises granular activated carbon.

71. The system of in claim 70, wherein the granular activated carbon is treated to provide affinity to predetermined chemical species, metals or other compounds found to be present in the influent wastewater.

72. The system of claim 70, wherein the adsorbent material further includes one or more of additional adsorbent materials selected from the group consisting of granular iron-based compounds, granular manganese-based compounds, granular alumino-silicate composites and synthetic resins.

73. The system of claim 68, further comprising

a solids separation apparatus in communication with the mixed liquor outlet,

a return activated sludge line for returning at least a portion of activated sludge from the solids separation apparatus to the biological regeneration reactor, and

a separation subsystem in the biological regeneration reactor or downstream of the biological regeneration reactor or between the biological regeneration reactor and the solids separation apparatus to introduce the biological regeneration reactor water effluent that is substantially free of adsorbent material to the solids separation apparatus.

74. The system of claim 73, wherein the solids separation apparatus of the low flux adsorbent material biological regeneration reactor is selected from the group consisting of a

membrane operating system, a clarifier, a settler, and a combination including at least one of a membrane operating system, a clarifier, or a settler.

75. The system of claim 73, wherein the adsorbent material has an effective granule size of at least about 0.3 millimeters.

76. The system of claim 73, wherein the adsorbent material has an effective granule size of at least about 0.5 millimeters.

77. The system of claim 68 wherein the low flux adsorbent material biological regeneration reactor system further comprises:

a shearing apparatus for shearing an accumulated biomass from adsorbent material to produce a mixture of a sheared adsorbent material and a free biomass, the shearing apparatus being positioned in at least one location selected from

within the biological regeneration reactor and

separate from the biological regeneration reactor and connected to the adsorbent material outlet for receiving a regenerated adsorbent material from the biological regeneration reactor;

an adsorbent material/biomass separation zone for separating the free biomass from the mixture of sheared adsorbent material and free biomass to produce a separated sheared adsorbent material and a free biomass;

an adsorbent material conduit for passing the separated sheared adsorbent material from the adsorbent material/biomass separation zone to the high flux adsorption system; and

a biomass conduit for passing free biomass from the adsorbent material/biomass separation zone to at least one of the biological regeneration reactor and a location downstream of the biological regeneration reactor.

78. The system of claim 68, wherein the low flux adsorbent material biological regeneration reactor system further comprises:

a combined apparatus for shearing and separating an accumulated biomass from a regenerated adsorbent material being positioned in at least one location selected from

within the biological regeneration reactor and

separate from the biological regeneration reactor and connected to the regenerated adsorbent material outlet for receiving the regenerated adsorbent material from the biological regeneration reactor, and having an outlet for discharging a separated sheared adsorbent material and an outlet for discharging a free biomass;

an adsorbent material conduit in communication with the regenerated adsorbent material outlet of the combined apparatus for returning regenerated adsorbent material to the high flux adsorption system; and

a biomass conduit in communication with the outlet for discharging the free biomass of the combined apparatus for passing free biomass to at least one of the biological regeneration reactor and a location downstream of the biological regeneration reactor.

79. The system of claim 68, wherein the low flux adsorbent material biological regeneration reactor system further comprises a membrane operating system in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

80. The system of claim 68, wherein the low flux adsorbent material biological regeneration reactor system further comprises at least one of a clarifier and a settler in fluid communication with the mixed liquor outlet of the biological regeneration reactor.

81. The system of claim 68, wherein the high flux adsorption system includes a mixing zone and a settling zone.

82. The system of claim 81, wherein the settling zone includes a vessel configured with an inverse conical or frusto-conical bottom portion, the adsorbent material outlet positioned in said inverse conical or frusto-conical bottom portion.

83. The system of claim 68, wherein the high flux adsorption system includes an adsorbent material filtration apparatus.

84. The system of claim 68, wherein the high flux adsorption system includes a continuous backwash filter.

85. The system of claim 68, wherein the high flux adsorption system includes at least one of a continuous regenerating filtration system and a continuous regenerating walnut shell filter.

86. The system of claim 68, further comprising an upstream wastewater treatment system that discharges a low concentration wastewater, and wherein the wastewater inlet of the mixing zone is a low concentration wastewater inlet fluidly connectable to the upstream wastewater treatment system.

87. The system of claim 68, further comprising

a sensor constructed and arranged to measure a parameter of the wastewater treatment system; and

a controller in electronic communication with the sensor programmed to instruct performance of an act based on the measured parameter of the system.

88. The wastewater treatment system of claim 87, wherein the measured parameter is the concentration of at least one predetermined compound.

89. The wastewater treatment system of claim 87, wherein the act comprises removing at least a portion of at least one of the adsorbent material having contaminants adsorbed thereon and regenerated adsorbent material from the biological regeneration reactor.

90. The wastewater treatment system of claim 87, wherein the act comprises adding adsorbent material to the biological regeneration reactor.