

WHAT IS CLAIMED IS:

1. A method of indirectly monitoring the concentration of ferrate in a flowing waste water stream, comprising:

diverting at least a portion of the flowing waste water stream into a dosing stream, wherein the volumetric flow rate of the flowing waste water stream and the volumetric flow rate of the dosing stream are at a fixed ratio;

adding ferrate to the dosing stream at a ferrate addition site;

monitoring the concentration of ferrate in the dosing stream using a spectrophotometer downstream of the ferrate addition site; and

combining the ferrate-containing dosing stream with the waste water stream, wherein the ferrate enters the waste water stream.

2. The method of Claim 0, further comprising the step of determining the concentration of ferrate in the waste water stream indirectly, as a function of (i) the concentration of the ferrate in the dosing stream and (ii) the ratio of the volumetric flow rates of the waste water stream and the dosing stream.

3. The method of any of Claims 0 to 2, wherein the volumetric flow rate ratio of the waste water stream to the dosing stream is in the range of about 3:1 to about 50:1.

4. The method of any of Claims 0 to 2, wherein the volumetric flow rate ratio of the waste water stream to the dosing stream is in the range of about 5:1 to about 25:1.

5. The method of any of Claims 0 to 4, wherein the concentration of ferrate in the dosing stream is measured substantially continuously.

6. An apparatus for monitoring low concentration ferrate in a treatment stream, comprising:

a treatment stream;

a dosing stream that is diverted off of the treatment stream, wherein the volumetric flow rate of the dosing stream is less than the volumetric flow rate of the treatment stream;

a ferrate dosing pump positioned along the dosing stream; and

a monitor flow cell positioned along the dosing stream at a position downstream from the ferrate dosing pump, wherein the monitor flow cell comprises a photometer.

7. The apparatus of Claim 6, further comprising a mixing device along the dosing stream positioned downstream from the ferrate metering pump and upstream from the monitor flow cell.

8. The apparatus of any of Claims 6 to 7, wherein the dosing stream is re-connected to the treatment stream at a position downstream from the monitor flow cell.

9. The apparatus of Claim 8, further comprising a second mixing device along the treatment stream, positioned downstream from the point where the dosing stream is re-connected to the treatment stream.

10. The apparatus of Claim 9, wherein the first and second mixing devices each independently comprise a mixer selected from the group consisting of mechanical mixers, hydraulic mixers, or sonic mixers.

11. The apparatus of any of Claims 6 to 10, wherein the photometer comprises a spectrophotometer.

12. The apparatus of any of Claims 6 to 11, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 3:1 to about 50:1.

13. The apparatus of any of Claims 6 to 11, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 5:1 to about 20:1.

14. A method of indirectly monitoring the concentration of a low concentration additive in a flowing treatment stream, comprising:

flowing at least a portion of the treatment stream into a dosing stream, wherein the volumetric flow rate of the treatment stream and the volumetric flow rate of the dosing stream are at a fixed ratio;

adding the additive to the dosing stream;

measuring the concentration of the additive in the dosing stream; and

combining the additive-containing dosing stream with the treatment stream.

15. The method of Claim 14, wherein the additive is one or more of an oxidant, a disinfectant, flocculent, or a coagulant.

16. The method of Claim 15, wherein the additive comprises ferrate.

17. The method of Claim 14, wherein the additive is a non-oxidant.

18. The method of Claim 17, wherein the non-oxidant is one or more of ferric, ferrous, or zero valent iron.

19. The method of any of Claims 14 to 18, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 3:1 to about 50:1.

20. The method of any of Claims 14 to 18, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 5:1 to about 25:1.

21. The method of any of Claims 14 to 20, further comprising the step of determining the concentration of the additive in the treatment stream indirectly, as a function of (i) the concentration of the additive in the dosing stream and (ii) the ratio of the volumetric flow rates of the treatment stream and the dosing stream.

22. The method of any of Claims 14 to 21, wherein the measurement of the additive concentration is performed using a photometer.

23. The method of Claim 22, wherein the photometric measurement of additive concentration is performed using a spectrophotometer at a wavelength in the range of about 310 nm to about 330 nm or in the range of about 500 nm to about 520 nm.

24. The method of any of Claims 14 to 23, wherein the concentration of the additive in the dosing stream is measured substantially continuously.

25. The method of any of Claims 14 to 24, wherein the treatment stream comprises a stream selected from the group consisting of waste water, ballast water, drinking water, reuse water, process water, ground water, produced water, sea water, brackish water, storm water, combined sewer overflow, and combinations thereof.

26. A method of adding a low-concentration additive to a treatment stream, comprising:

flowing the treatment stream;

diverting at least a portion of the treatment stream into a dosing stream, wherein the volumetric flow rate of the dosing stream is less than the volumetric flow rate of the treatment stream;

adding the additive at an initial concentration to the dosing stream; and

combining the additive-containing dosing stream with the treatment stream.

27. The method of Claim 26, wherein the additive is one or more of an oxidant, a disinfectant, a flocculent, or a coagulant.

28. The method of Claim 27, wherein the additive comprises ferrate.

29. The method of Claim 26, wherein the additive is a non-oxidant.

30. The method of Claim 29, wherein the non-oxidant is one or more of ferric, ferrous, or zero valent iron.

31. The method of any of Claims 26 to 30, wherein the volumetric flow rate ratio of the treatment stream to the dosing is in the range of about 3:1 to about 50:1.

32. The method of any of Claims 26 to 30, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 5:1 to about 25:1.

33. The method of any of Claims 26 to 32, wherein the treatment stream comprises a stream selected from the group consisting of waste water, ballast water, drinking water, reuse water, process water, ground water, produced water, sea water, brackish water, storm water, combined sewer overflow, and combinations thereof.

34. A method of controlling the concentration of an additive in a treatment stream, comprising:

diverting at least a portion of the treatment stream into a dosing stream, wherein the volumetric flow rate of the dosing stream is less than the volumetric flow rate of the treatment stream;

measuring an initial concentration of the additive in the dosing stream using a photometer;

adjusting the amount of the additive being added into the dosing stream based upon the measured initial concentration of the additive in the dosing stream; and

combining the additive-containing dosing stream with the treatment stream.

35. The method of Claim 34, wherein the additive is an oxidant.

36. The method of Claim 35, wherein the oxidant is ferrate.

37. The method of Claim 32, wherein the additive is a non-oxidant.

38. The method of Claim 37, wherein the non-oxidant is one or more of ferric, ferrous, or zero valent iron.

39. The method of any of Claims 34 to 38, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream during measurement of the initial concentration of the additive is in the range of about 3:1 to about 50:1.

40. The method of any of Claims 34 to 38, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream during measurement of the initial concentration of the additive is in the range of about 5:1 to about 25:1.

41. The method of any of Claims 34 to 40, wherein the amount of additive being added to the dosing stream is determined by the (i) the concentration of the additive in the dosing stream and (ii) the ratio of the volumetric flow rates of the treatment stream and the dosing stream.

42. The method of any of Claims 34 to 41, wherein the photometric measurement of additive concentration is a spectrophotometric measurement performed at a wavelength in the range of about 310 nm to about 330nm or in the range of about 500 nm to about 520 nm.

What is claimed is:

1. A method of indirectly monitoring the concentration of ferrate in a flowing waste water stream, comprising:
 - diverting at least a portion of the flowing waste water stream into a dosing stream, wherein the volumetric flow rate of the flowing waste water stream and the volumetric flow rate of the dosing stream are at a fixed ratio;
 - adding ferrate to the dosing stream at a ferrate addition site;
 - monitoring the concentration of ferrate in the dosing stream using a spectrophotometer downstream of the ferrate addition site; and
 - combining the ferrate-containing dosing stream with the waste water stream, wherein the ferrate enters the waste water stream.
2. An apparatus for monitoring low concentration ferrate in a treatment stream, comprising:
 - a treatment stream;
 - a dosing stream that is diverted off of the treatment stream, wherein the volumetric flow rate of the dosing stream is less than the volumetric flow rate of the treatment stream;
 - a ferrate dosing pump positioned along the dosing stream; and
 - a monitor flow cell positioned along the dosing stream at a position downstream from the ferrate dosing pump, wherein the monitor flow cell comprises a photometer.
3. The apparatus of Claim 2, further comprising a mixing device along the dosing stream positioned downstream from the ferrate metering pump and upstream from the monitor flow cell.
4. The apparatus of any of Claims 2 to 3, wherein the dosing stream is re-connected to the treatment stream at a position downstream from the monitor flow cell.
5. The apparatus of Claim 4, further comprising a second mixing device along the treatment stream, positioned downstream from the point where the dosing stream is re-connected to the treatment stream.
6. The apparatus of Claim 5, wherein the first and second mixing devices each independently comprise a mixer selected from the group consisting of mechanical mixers, hydraulic mixers, or sonic mixers.
7. A method of indirectly monitoring the concentration of a low concentration additive in a flowing treatment stream, comprising:
 - flowing at least a portion of the treatment stream into a dosing stream, wherein the volumetric flow rate of the treatment stream and the volumetric flow rate of the dosing stream are at a fixed ratio;
 - adding the additive to the dosing stream;
 - measuring the concentration of the additive in the dosing stream; and
 - combining the additive-containing dosing stream with the treatment stream.
8. The method of Claim 7, wherein the additive is one or more of an oxidant, a disinfectant, flocculent, or a coagulant.
9. The method of Claim 8, wherein the additive comprises ferrate.
10. The method of Claim 7, wherein the additive is a non-oxidant.
11. The method of Claim 10, wherein the non-oxidant is one or more of ferric, ferrous, or zero valent iron.

12. The method of any of Claims 7 to 11, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 3:1 to about 50:1.

13. The method of any of Claims 7 to 11, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 5:1 to about 25:1.

14. A method of adding a low-concentration additive to a treatment stream, comprising:

flowing the treatment stream;

diverting at least a portion of the treatment stream into a dosing stream, wherein the volumetric flow rate of the dosing stream is less than the volumetric flow rate of the treatment stream;

adding the additive at an initial concentration to the dosing stream; and

combining the additive-containing dosing stream with the treatment stream.

15. The method of Claim 14, wherein the additive is one or more of an oxidant, a disinfectant, a flocculent, or a coagulant.

16. The method of Claim 15, wherein the additive comprises ferrate.

17. The method of Claim 14, wherein the additive is a non-oxidant.

18. The method of Claim 17, wherein the non-oxidant is one or more of ferric, ferrous, or zero valent iron.

19. The method of any of Claims 14 to 18, wherein the volumetric flow rate ratio of the treatment stream to the dosing is in the range of about 3:1 to about 50:1.

20. The method of any of Claims 14 to 18, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream is in the range of about 5:1 to about 25:1.

21. A method of controlling the concentration of an additive in a treatment stream, comprising:

diverting at least a portion of the treatment stream into a dosing stream, wherein the volumetric flow rate of the dosing stream is less than the volumetric flow rate of the treatment stream;

measuring an initial concentration of the additive in the dosing stream using a photometer;

adjusting the amount of the additive being added into the dosing stream based upon the measured initial concentration of the additive in the dosing stream; and

combining the additive-containing dosing stream with the treatment stream.

22. The method of Claim 21, wherein the additive is an oxidant.

23. The method of Claim 22, wherein the oxidant is ferrate.

24. The method of any of Claims 21 to 23, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream during measurement of the initial concentration of the additive is in the range of about 3:1 to about 50:1.

25. The method of any of Claims 21 to 23, wherein the volumetric flow rate ratio of the treatment stream to the dosing stream during measurement of the initial concentration of the additive is in the range of about 5:1 to about 25:1.