CLAIMS

1. A water treatment system for wastewater comprising:

an actinic radiation reactor comprising at least three reactor chambers serially arranged, wherein each reactor chamber includes at least one ultraviolet gas discharge (UV) lamp disposed to irradiate the wastewater in the reactor chamber with light in the range of 185 nm to 220 nm;

an electrochemical cell configured to produce hydrogen peroxide and having an outlet in fluid communication between a source of electrolyte and the actinic radiation reactor; and

a source of oxygen in communication with an inlet of the electrochemical cell.

2. The system of claim 1, further comprising:

a first conduit fluidically coupling the source of electrolyte to the inlet of the electrochemical cell; and

a second conduit fluidically coupling the outlet of the electrochemical cell to an inlet of the actinic radiation reactor.

3. The system of claim 1, wherein the outlet of the electrochemical cell is fluidically coupled to a point of introduction in a conduit fluidically coupling the source of electrolyte to the inlet of the electrochemical cell.

4. The system of claim 1, wherein, for at least one reactor chamber, the light is in the range of 190 nm to 200 nm.

5. The system of claim 1, wherein the electrolyte comprises water.

6. The system of claim 1, further comprising a storage tank coupled to the outlet of the electrochemical cell.

7. The system of claim 1, further comprising:

a conduit fluidically coupled to an outlet of the actinic radiation reactor; and

a second electrochemical cell having an outlet in fluid communication with the conduit downstream of the outlet of the actinic radiation reactor, the second electrochemical cell configured to produce a chemical agent that quenches hydrogen peroxide present in a treated aqueous solution in the conduit.

8. The system of claim 7, further comprising a storage tank coupled to the outlet of the second electrochemical cell.

9. The system of claim 7, wherein the chemical agent includes sodium hypochlorite.

10. The system of claim 7, wherein the conduit fluidically couples the outlet of the actinic radiation reactor to an inlet of the second electrochemical cell.

11. The system of claim 7, wherein the outlet of the second electrochemical cell is fluidically coupled to a point of introduction in the conduit downstream of the outlet of the actinic radiation reactor.

12. The system of any of claims 1-11, further comprising a sensor configured to measure a concentration of one or more contaminants in an aqueous solution, the sensor positioned one of upstream of the actinic radiation reactor or downstream of the actinic radiation reactor.

13. The system of claim 12, further comprising a controller in communication with the sensor and configured to adjust one or more operating parameters of the system responsive to a measured concentration of the one or more contaminants.

14. The system of claim 13, wherein the one or more operating parameters including one of power applied to the electrochemical cell, power applied to the second electrochemical cell, power applied to the actinic radiation reactor, and flow

rate of electrolyte or aqueous solution through one of the electrochemical cell, the second electrochemical cell, or the actinic radiation reactor.

15. The system of claim 13, wherein the source of oxygen is configured to introduce the oxygen into the electrolyte upstream of the electrochemical cell.

16. The system of claim 15, wherein the controller is further configured to regulate a rate of introduction of the oxygen into the electrolyte responsive to the measured concentration of the one or more contaminants.

17. The system of claim 6, further comprising a controller configured to adjust a flow rate of hydrogen peroxide from the storage tank into the actinic radiation reactor based on one or more measured characteristics of electrolyte from the source of electrolyte or one or more measured characteristics of a treated aqueous solution generated in the actinic radiation reactor.

18. The system of claim 8, further comprising a controller configured to adjust a flow rate of sodium hypochlorite from the storage tank into the conduit downstream of the outlet of the actinic radiation reactor based on one or more measured characteristics of electrolyte from the source of electrolyte or one or more measured characteristics of a treated aqueous solution generated in the actinic radiation reactor.

19. The system of any of claims 1-11, further comprising a sensor configured to measure a concentration of hydrogen peroxide in treated aqueous solution downstream of the actinic radiation reactor.

20. A method of treating wastewater in a water treatment system, the method comprising:

directing the wastewater to be treated from a source of wastewater into a conduit fluidically coupled to an outlet of an electrochemical cell;

adding hydrogen peroxide generated in the electrochemical cell to the wastewater to be treated to form an aqueous solution including hydrogen peroxide;

directing the aqueous solution into an inlet of an actinic radiation reactor comprising at least three reactor chambers serially arranged, wherein each reactor chamber includes at least one ultraviolet gas discharge (UV) lamp disposed to irradiate the wastewater in the reactor chamber with light in the range of 185 nm to 220 nm;

exposing the aqueous solution to sufficient actinic radiation in the actinic radiation reactor to generate free radicals in the aqueous solution which react with contaminants in the aqueous solution to form a treated aqueous solution; and

directing the treated aqueous solution through a second conduit from an outlet of the actinic radiation reactor to a point of use.

21. The method of claim 20, wherein directing the wastewater to be treated from the source of wastewater into the conduit fluidically coupled to the outlet of the electrochemical cell includes directing the wastewater to be treated into an inlet of the electrochemical cell.

22. The method of claim 21, further comprising:

applying power across electrodes of the electrochemical cell to convert oxygen in the wastewater to be treated to hydrogen peroxide in the electrochemical cell and form the aqueous solution including hydrogen peroxide; and

directing the aqueous solution from an outlet of the electrochemical cell into the inlet of the actinic radiation reactor.

23. The method of claim 20, wherein, for at least one reactor chamber, the light is in the range of 190 nm to 200 nm.

24. The method of claim 20, wherein directing the treated aqueous solution to the point of use includes directing the treated aqueous solution to the source of wastewater.

25. The method of claim 20, further comprising adding oxygen to the wastewater to be treated upstream of the inlet of the electrochemical cell.

26. The method of claim 20, further comprising:

recirculating the aqueous solution through a recirculation conduit from the outlet of the electrochemical cell to the inlet of the electrochemical cell for additional treatment in the electrochemical cell, the additional treatment increasing a concentration of hydrogen peroxide in the aqueous solution;

directing the wastewater to be treated from a second source of wastewater to be treated through a first conduit into the inlet of the actinic radiation reactor; and

providing selective fluid communication from the recirculation conduit to a point of introduction in the first conduit upstream of the inlet of the actinic radiation reactor.

27. The method of claim 26, further comprising measuring a concentration of the hydrogen peroxide in the recirculation conduit with a sensor.