CLAIMS

What is claimed is:

1. A device for sulfide removal from water or wastewater, comprising:

a manifold structure including one or more openings to flow air out of an interior of the manifold structure;

one or more support structures connected to the manifold structure, wherein the one or more support structures are configured to float the manifold structure on a surface of a fluid including water or wastewater or to partially submerge the manifold structure below the surface of the fluid; and

an air source configured to supply air to the manifold structure to be flowed out from the manifold structure through the one or more openings at the fluid to facilitate sulfide in the fluid to oxidize,

wherein the device is configured to expel the air from the one or more openings of the manifold structure (i) at a top surface of the fluid, (ii) at a shallow depth within a range between 0 cm to 5 cm below the top surface of the fluid, or (iii) both at the top surface and at the shallow depth of the fluid, such that the air supplied by the air source is configured to provide an amount of oxygen gas within the shallow depth of the fluid comprising less than 0.1 mg/L of oxygen (O_2).

2. The device of claim 1, wherein the manifold structure includes multiple channels for the air to flow out of the interior of the manifold structure.

3. The device of claim 1, wherein the air source includes a pump in connection to a tube that supplies air to the manifold structure.

4. The device of claim 1, further comprising: a flow meter to control a rate of air flow.

5. The device of claim 1, wherein the manifold structure is configured to have a ring geometry or a polygon geometry.

6. The device of claim 1, wherein the manifold structure includes a plurality of tubular

structures spanning from a feed tube, where the tubular structures have the one or more openings to flow air out of the interior of the tubular structure.

7. The device of claim 1, further comprising: a support material coupled to the manifold structure to facilitate growth of sulfide-oxidizing bacteria to create a biofilm, wherein the support material includes a plurality of openings such that the support material has an open structure up to 90% of the structure.

8. The device of claim 7, wherein the support material includes a perforated carbon textile, a plastic mesh, or a perforated foam.

9. The device of claim 7, wherein the support material is configured to float on the surface of the fluid.

10. The device of claim 1, wherein the one or more support structures is porous, biocompatible, and/or inert in water.

11. The device of claim 1, wherein the one or more support structures includes a foam.

12. The device of claim 1, further comprising:

a container to hold the fluid, wherein the container is interfaced with an inlet line through which the fluid can flow into the container and an outlet line through which, once treated, the fluid can flow out of the container; and

a lid to at least partially cover the container and define a volume in the container between the manifold structure and the lid that allows for uniform distribution of the air (i) at the top surface of the fluid, (ii) at the shallow depth below the top surface of the fluid, or (iii) both at the top surface and at the shallow depth of the fluid.

13. The device of claim 1, wherein the one or more openings of the manifold structure is configured to provide uniform air distribution on the surface of the fluid.

14. A method of removing sulfide from a fluid containing water or wastewater, the method comprising:

contacting a fluid in a container containing water or wastewater with a manifold structure that includes one or more openings to flow air out of an interior of the manifold structure, wherein the manifold structure is positioned with respect to the fluid on one or more support structures connected to the manifold structure and configured to float the manifold structure on a surface of or partially submerge the manifold structure below the surface of the fluid;

micro-aerating the fluid in the container by expelling air out of the one or more openings of the manifold structure to supply the air (i) at a top surface of the fluid, (ii) at a shallow depth within a range between 0 cm to 5 cm below the top surface of the fluid, or (iii) both at the top surface and at the shallow depth of the fluid, such that an amount of oxygen gas within the shallow depth of the fluid comprises less than 0.1 mg/L of oxygen (O_2) in the fluid; and

converting sulfide of the fluid in the container to elemental sulfur.

15. The method of claim 14, wherein the fluid includes sulfide-oxidizing bacteria.

16. The method of claim 14, comprising regulating air flow with a flow meter for flowing air out of the interior of the manifold structure, wherein the air flow is regulated such that a concentration of oxygen introduced into the fluid containing the water or wastewater does not exceed 0.1 mg/L.

17. The method of claim 14, comprising providing a support material coupled to the manifold structure to facilitate growth of sulfide-oxidizing bacteria on the support material to create a biofilm.

18. The method of claim 14, wherein the method does not convert sulfide to sulfate, thiosulfate, or combination thereof.

19. The method of claim 14, wherein the sulfide is hydrogen sulfide.

20. The method of claim 14, wherein the micro-aerating the fluid controls the supply of air at the top surface and within the shallow depth without aerating a main body of the fluid and thus disturbing an anaerobic treatment process.

21. The method of claim 14, further comprising: enclosing the container, at least partially, to define a volume in the container between the manifold structure and the lid that allows for uniform distribution of the air (i) at the top surface of the fluid, (ii) at the shallow depth below the top surface of the fluid, or (iii) both at the top surface and at the shallow depth of the fluid.

22. A system for sulfide removal from and treatment of wastewater, comprising:

a container configured to hold a fluid including a wastewater, wherein the container is interfaced with an inlet line through which the fluid can flow into the container and an outlet line through which, once pre-treated, the fluid can flow out of the container as a pre-treated fluid;

a micro-aeration device configured to float on the fluid in the container, the micro-aeration device comprising (i) a manifold structure including one or more openings to flow air out of an interior of the manifold structure, (ii) one or more support structures connected to the manifold structure, wherein the one or more support structures are configured to float the manifold structure on a surface of the fluid or partially submerge the manifold structure below the surface of the fluid, and (iii) an air source configured to supply air to the manifold structure to be flowed out from the manifold structure through the one or more openings at the fluid to facilitate conversion of sulfide in the fluid to elemental sulfur to produce treated fluid, wherein the micro-aeration device is configured to expel the air from the one or more openings of the manifold structure (i) at a top surface of the fluid, (ii) at a shallow depth within a range between 0 cm to 5 cm below the top surface of the fluid, or (iii) both at the top surface and at the shallow depth of the fluid, such that the air supplied by the air source is configured to provide an amount of oxygen gas within the shallow depth of the fluid comprising less than 0.1 mg/L of oxygen (O_2) in the fluid; and

a microbial fuel cell (MFC) device configured to receive the pre-treated fluid via the outlet line, the MFC device configured to bioelectrochemically process the pre-treated fluid to concurrently generate electrical energy and digest organic matter in the pre-treated fluid to yield a treated water, wherein the MFC device comprises a housing, and a bioelectrochemical reactor encased within the housing, the bioelectrochemical reactor including a plurality of anodes arranged between a cathode assembly that comprises two cathodes separated on opposite sides of the plurality of anodes and arranged along a flow direction of the pre-treated fluid.

23. The system of claim 22, wherein the micro-aeration device further includes a flow meter to control a rate of air flow.

24. The system of claim 22, wherein the micro-aeration device further includes a support material coupled to the manifold structure to facilitate growth of sulfide-oxidizing bacteria to create a biofilm, wherein the support material includes a plurality of openings such that the support material has an open structure up to 90% of the structure.

25. The system of claim 22, wherein the manifold structure includes multiple channels for the air to flow out of the interior of the manifold structure.

26. The system of claim 22, wherein the manifold structure is configured to have a ring geometry or a polygon geometry.

27. The system of claim 22, wherein the manifold structure includes a plurality of tubular structures spanning from a feed tube, where the tubular structures have the one or more openings to flow air out of the interior of the tubular structure.

28. The system of claim 22, further comprising:

a lid to at least partially cover the container and define a volume in the container between the micro-aeration device and the lid that allows for uniform distribution of the air (i) at the top surface of the fluid, (ii) at the shallow depth below the top surface of the fluid, or (iii) both at the top surface and at the shallow depth of the fluid.

29. A device for sulfide removal from water or wastewater, comprising:

a manifold structure including one or more openings to flow air out of an interior of the manifold structure;

one or more support structures connected to the manifold structure, wherein the one or more support structures are configured to float the manifold structure on or above a surface of a fluid including water or wastewater, such that the one or more openings to flow the air out are above the surface; and

an air source configured to supply air to the manifold structure to be flowed out from the manifold structure through the one or more openings at the fluid to facilitate sulfide in the fluid to oxidize,

wherein the device is configured to expel the air from the one or more openings of the manifold structure at a top surface of the fluid, such that the air supplied by the air source is configured to provide an amount of oxygen gas within a shallow depth of the fluid comprising less than 0.1 mg/L of oxygen (O_2), wherein the shallow depth includes a range between 0 cm to 5 cm below the top surface of the fluid.

30. The device of claim 29, further comprising:
a support material coupled to the manifold structure to facilitate growth of sulfide-oxidizing bacteria to create a biofilm, wherein the support material includes a plurality of openings such that the support material has an open structure up to 90% of the structure.

31. The device of claim 29, wherein the manifold structure includes a plurality of tubular structures spanning from a feed tube, where the tubular structures have the one or more openings to flow air out of the interior of the tubular structure.

32. The device of claim 29, further comprising:
a container to hold the fluid; and
a lid to at least partially cover the container and define a volume in the container between the manifold structure and the lid that allows for uniform distribution of the air at the top surface of the fluid.

33. The device of claim 29, wherein the one or more openings of the manifold structure is configured to provide uniform air distribution on the surface of the fluid.