

Claims:

1. A device for reducing biofouling in a water system, comprising:
 - a treatment unit comprising at least one layer of a permeable fabric structure having an outer surface, an inner surface and a plurality of pores extending therebetween, the permeable fabric structure having a biocide coating on at least one surface which extends at least partially into the plurality of pores,
 - the treatment unit positioned at a water intake location of the water system, wherein all of the water passing through the water system passes through the treatment unit,
 - the water requiring an average dwell time to travel through the treatment unit and the water system and be expelled from a water discharge of the water system,
 - wherein the biocide coating elutes a biocide into the water passing through the treatment unit, the biocide contacting at least one fouling organism in the water and reducing fouling on one or more substrate surfaces within the water system for at least the average dwell time.
2. The device of claim 1, wherein the coated permeable fabric structure within the treatment unit has a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.
3. The device of claim 1, wherein the at least one layer of the permeable fabric structure comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.
4. The device of claim 1, wherein a dissolved oxygen content of the water located immediately upstream from the treatment unit is substantially similar to a dissolved oxygen content of the water located immediately downstream from the treatment unit.
5. The device of claim 1, wherein a dissolved oxygen content of the water located immediately upstream from the treatment unit is substantially higher than a dissolved oxygen content of the water located immediately downstream from the treatment unit.
6. The device of claim 1, wherein the biocide coating is on an upstream outer surface of the permeable fabric structure.

7. The device of claim 6, wherein a downstream outer surface of the permeable fabric treatment unit is substantially free of the biocide coating.

8. The device of claim 1, wherein the water system comprises a once-through system.

9. The device of claim 1, wherein the water system comprises a recirculation system.

10. The device of claim 1, wherein the water system comprises a make-up water circuit of a recirculation system.

11. A method of reducing biofouling on a substrate in a flowing water stream, comprising:

applying a coating comprising a biocide to a surface of an enclosure, the enclosure having a plurality of pores extending from the first surface to a second surface of the enclosure, wherein the coating extends into the plurality of pores such that the plurality of pores have an average pre-coating minimum pore opening of at least 25 micrometers and an average post-coating minimum pore opening between 75 and 25 micrometers,

placing the coated enclosure in the flowing water stream, wherein the flowing water stream flows through the plurality of pores from the first surface to the second surface and the biocide elutes from the coating into the water stream, the biocide contacting biofouling organisms and reducing biofouling organisms from colonizing on a substrate surface positioned downstream from the coated enclosure.

12. The method of claim 11, wherein the enclosure comprises a flexible fabric material having a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.

13. The method of claim 11, wherein the flexible fabric material comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.

14. The method of claim 11, wherein a dissolved oxygen content of a portion of the flowing water stream located upstream from the enclosure is substantially similar to a dissolved oxygen content of a portion of the flowing water stream located downstream from the enclosure.

15. The method of claim 11, wherein a dissolved oxygen content of a portion of the flowing water stream located upstream from the enclosure is substantially higher than a dissolved oxygen content of a portion of the flowing water stream located downstream from the enclosure.
16. The method of claim 11, wherein the biocide coating is on an upstream outer surface of the enclosure.
17. The method of claim 16, wherein a downstream outer surface of the permeable fabric filter media is substantially free of the biocide coating.
18. The method of claim 11, wherein the enclosure is positioned within a water intake of a once-through system.
19. The method of claim 11, wherein the enclosure is positioned within a water intake of a recirculation system.
20. The method of claim 11, wherein the enclosure is positioned within a make-up water circuit of a recirculation system.
21. A device for reducing biofouling in a water system, comprising:
 - a filtration and treatment unit comprising:
 - at least one layer of a permeable filter media having an outer surface, an inner surface and a plurality of pores extending therebetween, the permeable filter media having a biocide coating on the outer surface which extends at least partially into the plurality of pores, and
 - an oxygen removal system that removes at least a portion of the dissolved oxygen in water passing through the filtration unit;
 - the filtration unit positioned at the water intake location of the water system,wherein all of the water entering the water system passes through the filtration unit, the water requiring an average dwell time to travel through the filtration unit and the water system and be expelled from a water discharge of the water system,
 - wherein the biocide coating elutes a biocide into the water passing through the filtration and treatment unit, the biocide contacting a plurality of fouling organisms in the water and inhibiting an ability of the plurality of fouling organisms to colonize one or more substrate surfaces within the water system for at least the average dwell time.

22. The device of claim 21, wherein the permeable fabric filter media within the filtration unit has a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.
23. The device of claim 21, wherein the at least one layer of the permeable fabric filter media comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.
24. The device of claim 21, wherein a dissolved oxygen content of the water located immediately upstream from the filtration unit is substantially similar to a dissolved oxygen content of the water located immediately downstream from the filtration unit.
25. The device of claim 21, wherein a dissolved oxygen content of the water located immediately upstream from the filtration unit is substantially higher than a dissolved oxygen content of the water located immediately downstream from the filtration unit.
26. The device of claim 21, wherein the biocide coating is on an upstream outer surface of the permeable fabric filter media.
27. The device of claim 21, wherein a downstream outer surface of the permeable fabric filter media is substantially free of the biocide coating.
28. The device of claim 21, wherein the water system comprises a once-through system.
29. The device of claim 21, wherein the water system comprises a recirculation system.
30. The device of claim 21, wherein the water system comprises a make-up water circuit of a recirculation system.
31. A method of reducing biofouling from a plurality of biofouling organisms in a cooling water stream which experiences elevated temperatures, comprising:
- applying a coating comprising a biocide to a first surface of a flexible porous fabric, the flexible porous fabric having a plurality of pores extending from the first surface to a second surface of the flexible porous fabric,
 - placing the coated fabric in the cooling water stream, wherein the cooling water stream flows through the plurality of pores from the first surface to the second surface at a first average water temperature and the biocide elutes from the coating into the cooling water stream, the biocide contacting the plurality of biofouling organisms and inhibiting the

plurality of biofouling organisms from colonizing a substrate surface positioned downstream from the coated fabric,

wherein the cooling water stream enters a cooling water circuit and is heated to a second average temperature, the second average temperature being higher than the first average temperature, and the effectiveness of the biocide in inhibiting the plurality of biofouling organisms from colonizing a substrate is not reduced by the increased average temperature of the cooling water stream.

32. The method of claim 31, wherein the flexible porous fabric comprises a material having a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.

33. The method of claim 31, wherein the flexible porous fabric comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.

34. The method of claim 31, wherein a dissolved oxygen content of a portion of the cooling water stream located upstream from the flexible porous fabric is substantially similar to a dissolved oxygen content of a portion of the cooling water stream located downstream from the flexible porous fabric.

35. The method of claim 31, wherein a dissolved oxygen content of a portion of the cooling water stream located upstream from the flexible porous fabric is substantially higher than a dissolved oxygen content of a portion of the cooling water stream located downstream from the flexible porous fabric.

36. The method of claim 31, wherein the biocide coating is on an upstream outer surface of the flexible porous fabric.

37. The method of claim 36, wherein a downstream outer surface of the flexible porous fabric is substantially free of the biocide coating.

38. The method of claim 31, wherein the flexible porous fabric is positioned within a water intake of a once-through cooling system.

39. The method of claim 31, wherein the flexible porous fabric is positioned within a water intake of a recirculation cooling system.

40. The method of claim 31, wherein the flexible porous fabric is positioned within a make-up water circuit of a recirculation cooling system.
41. An artificially created biofilm, comprising:
an antifouling biofilm formed within a water system, wherein water flowing within said water system periodically passes through a filtration and treatment unit comprising at least one layer of a permeable fabric filter media having an outer surface, an inner surface and a plurality of pores extending therebetween, the permeable fabric filter media having a biocide coating on the outer surface which extends at least partially into the plurality of pores, wherein the biocide elutes into the water and inhibits organisms from colonizing one or more substrate surfaces positioned within or downstream from the filtration and treatment unit, wherein said antifouling biofilm comprises a reduction in diversity of at least one cyanobacteria, diatom or bacteria compared to a naturally created biofilm in water outside of the water system.
42. The artificially created biofilm of claim 41, wherein the antifouling biofilm deposited on the substrate is thinner than a naturally occurring biofilm in water outside of the water system.
43. The method of claim 41, wherein the antifouling biofilm deposited on the substrate has a weaker structural integrity than a naturally occurring biofilm in water outside of the water system.
44. The method of claim 41, wherein the antifouling biofilm deposited on the substrate comprises predominantly Proteobacteria or Bacteroidetes.
45. The method of claim 41, wherein the antifouling biofilm deposited on the substrate comprises very low quantities of Verrucomicrobia and Actinobacteria.
46. A method of reducing microbiologically influenced corrosion (MIC) from a plurality of biofouling organisms in a water stream of a water system, comprising:
applying a coating comprising a biocide to a first surface of a flexible porous fabric, the flexible porous fabric having a plurality of pores extending from the first surface to a second surface of the flexible porous fabric,
placing the coated fabric in the water stream, wherein the water stream flows through the plurality of pores from the first surface to the second surface and the biocide elutes from the coating into the water stream, the biocide contacting at least one biofouling

organism and reducing biofouling organisms from colonizing on at least one substrate surface positioned downstream from the coated fabric.

47. The method of claim 46, wherein the flexible porous fabric comprises a material having a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.

48. The method of claim 46, wherein the flexible porous fabric comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.

49. The method of claim 46, wherein a dissolved oxygen content of a portion of the water stream located upstream from the flexible porous fabric is substantially similar to a dissolved oxygen content of a portion of the water stream located downstream from the flexible porous fabric.

50. The method of claim 46, wherein a dissolved oxygen content of a portion of the water stream located upstream from the flexible porous fabric is substantially higher than a dissolved oxygen content of a portion of the water stream located downstream from the flexible porous fabric.

51. The method of claim 46, wherein the biocide coating is on an upstream outer surface of the flexible porous fabric.

52. The method of claim 46, wherein a downstream outer surface of the flexible porous fabric is substantially free of the biocide coating.

53. The method of claim 46, wherein the flexible porous fabric is positioned within a water intake of a once-through water system.

54. The method of claim 46, wherein the flexible porous fabric is positioned within a water intake of a recirculation water system.

55. The method of claim 54, wherein the flexible porous fabric is positioned within a make-up water system of a recirculation system.

55. A device for reducing the occurrence of legionella in a cooling water flowing in a cooling water circuit of a manufacturing or power plant, comprising:

a filtration and treatment unit comprising:

at least one layer of a permeable fabric filter media having an outer surface, an inner surface and a plurality of pores extending therebetween, the permeable

fabric filter media having a biocide coating on the outer surface which extends at least partially into the plurality of pores, and

an oxygen removal system that removes at least a portion of the dissolved oxygen in cooling water passing through the filtration unit;

the filtration unit positioned at a cooling water filtration location of the cooling water circuit, wherein at least some portion of the cooling water in the cooling water circuit passes through the filtration unit,

wherein the biocide coating elutes a biocide into the cooling water passing through the filtration unit, the biocide contacting a plurality of legionella organisms in the cooling water and inhibiting an ability of the plurality of legionella organisms to thrive or colonize one or more substrate surfaces within the cooling water circuit.

56. The device of claim 55, wherein the permeable fabric filter media within the filtration and treatment unit has a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.

57. The device of claim 56, wherein the at least one layer of the permeable fabric filter media comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.

58. The device of claim 56, wherein a dissolved oxygen content of the cooling water located immediately upstream from the filtration and treatment unit is substantially similar to a dissolved oxygen content of the cooling water located immediately downstream from the filtration and treatment unit.

59. The device of claim 56, wherein a dissolved oxygen content of the cooling water located immediately upstream from the filtration unit is substantially higher than a dissolved oxygen content of the cooling water located immediately downstream from the filtration unit.

60. The device of claim 56, wherein the biocide coating is on an upstream outer surface of the permeable fabric filter media.

61. The device of claim 56, wherein a downstream outer surface of the permeable fabric filter media is substantially free of the biocide coating.

62. The device of claim 56, wherein the cooling water circuit comprises a once-through cooling system.
63. The device of claim 56, wherein the cooling water circuit comprises a recirculation cooling system.
64. The device of claim 56, wherein the cooling water circuit comprises a make-up water circuit of a recirculation cooling system.
65. A method of reducing biofilm formation within tubing of a water system, comprising:
applying a coating comprising a biocide to a first surface of a flexible porous fabric, the flexible porous fabric having a plurality of pores extending from the first surface to a second surface of the flexible porous fabric, and placing the coated fabric in a water stream of the water system at a location upstream from the tubing, wherein the water stream flows through the plurality of pores from the first surface to the second surface and the biocide elutes from the coating into the water stream, the biocide contacting a plurality of biofouling organisms within the water stream and inducing the formation of a reduced thickness biofilm on an interior surface of the tubing as compared to an untreated biofilm thickness from an untreated water flow.
66. The method of claim 65, wherein the flexible porous fabric has a permeability with the range of 5 milliliters of water per second per square centimeter to 100 milliliters of water per second per square centimeter.
67. The method of claim 65, wherein the at least one layer of the flexible porous fabric comprises a 3-dimensional flexible material selected from the group consisting of natural and synthetic fabrics, natural and synthetic membranes, natural and synthetic sheets, and fabrics, membranes, films and sheets made from a combination of natural and synthetic materials.
68. The method of claim 65, wherein a dissolved oxygen content of the water located immediately upstream from the flexible porous fabric is substantially similar to a dissolved oxygen content of the water located immediately downstream from the flexible porous fabric.
69. The method of claim 65, wherein a dissolved oxygen content of the water located immediately upstream from the flexible porous fabric is substantially higher than a dissolved oxygen content of the water located immediately downstream from the flexible porous fabric.

70. The method of claim 65, wherein the biocide coating is on an upstream outer surface of the flexible porous fabric.
71. The method of claim 65, wherein a downstream outer surface of the flexible porous fabric is substantially free of the biocide coating.
72. The method of claim 65, wherein the reduced thickness biofilm has a weaker structural integrity than the untreated biofilm.
73. The method of claim 65, wherein the reduced thickness biofilm comprises predominantly Proteobacteria or Bacteroidetes.
74. The method of claim 65, wherein the reduced thickness biofilm comprises very low quantities of Verrucomicrobia and Actinobacteria.