CLAIMS

1. A deionized water manufacturing system that is supplied with raw water and that manufactures deionized water, comprising:

a reverse-osmosis membrane device to which raw water is supplied; and

an electrodeionization device that includes a deionization chamber which is partitioned by an ion exchange membrane and to which permeated water of the reverse-osmosis membrane device is supplied,

wherein an ion exchanger is packed inside the deionization chamber,

wherein particles containing polyvalent metal are adsorbed to at least one surface of at least one portion of the ion exchange membrane and at least one portion of the ion exchanger, and

wherein the particles are composed of at least one of aluminium silicate, magnesium silicate, calcium silicate, calcium-magnesium silicate, aluminosilicate, and a silicate mineral.

2. The deionized water manufacturing system as set forth in claim 1, wherein the particles are composed of at least one of attapulgite, sepiolite, and wollastonite.

3. A deionized water manufacturing system that is supplied with raw water and that manufactures deionized water, comprising:

a reverse-osmosis membrane device to which raw water is supplied; and

an electrodeionization device that includes a deionization chamber which is partitioned by an ion exchange membrane and to which permeated water of the reverse-osmosis membrane device is supplied,

wherein an ion exchanger is packed inside the deionization chamber,

wherein particles containing polyvalent metal are adsorbed to at least one surface of at least one portion of the ion exchange membrane and at least one portion of the ion exchanger, and

wherein a diameter of the particles is at least 0.01 μm but no greater than 100 μm.

4. The deionized water manufacturing system as set forth in any one of claims 1 to 3, wherein the ion exchanger packed in the deionization chamber is either one of an anion exchanger and a cation exchanger.

5. The deionized water manufacturing system as set forth in any one of claims 1to 3, wherein, in the deionization chamber, a cation exchanger and an anion exchanger are alternately arranged along a direction of flow of water in the deionization chamber.

6. The deionized water manufacturing system as set forth in any one of claims 1 to 5, wherein the reverse-osmosis membrane device comprises a configuration in which devices each equipped with a reverse-osmosis membrane are connected in a two-pass series.

7. The deionized water manufacturing system as set forth in any one of claims 1 to 6, wherein, in the permeated water that is supplied to the deionization chamber of the electrodeionization device, sodium concentration is 100 μg/L or less, and silica concentration is 50 μg/L or less.

8. The deionized water manufacturing system as set forth in any one of claims 1 to 7, wherein a conductivity of the permeated water that is supplied to the deionization chamber of the electrodeionization device is 3 μS/cm or less.

9. The deionized water manufacturing system as set forth in any one of claims 1 to 8, further comprising an additional electrodeionization device between the reverse-osmosis membrane device and the electrodeionization device,

wherein the permeated water of the reverse-osmosis membrane device is supplied to the deionization chamber of the electrodeionization device by way of a deionization chamber of the additional electrodeionization device.

10. The deionized water manufacturing system as set forth in claim 9, wherein the electrodeionization device is operated such that the boron concentration in deionized water that is discharged from the deionization chamber of the electrodeionization device is 10 ng/L or less.

11. An electrodeionization device that is equipped with at least one deionization chamber between an anode chamber that is provided with an anode and a cathode chamber that is provided with a cathode, the deionization chamber being partitioned by an anion exchange membrane that is positioned on a side facing the anode and a cation exchange membrane that is positioned on a side facing the cathode, and at least one of an anion exchanger and a cation exchanger being packed inside the deionization chamber, characterized in that:

particles containing polyvalent metal are caused to adsorb to at least one surface of the anion exchange membrane, the cation exchange membrane, the anion exchanger, and the cation exchanger, and

the particles are composed of at least one of aluminum silicate, magnesium silicate, calcium silicate, calcium-magnesium silicate, aluminosilicate, and a silicate mineral.

12. The electrodeionization device as set forth in claim 11, wherein the particles are composed of at least one of attapulgite, sepiolite, and wollastonite.

13. An electrodeionization device that is equipped with at least one deionization chamber between an anode chamber that is provided with an anode and a cathode chamber that is provided with a cathode, the deionization chamber being partitioned by an anion exchange membrane that is positioned on a side facing the anode and a cation exchange membrane that is positioned on a side facing the cathode, and at least one of an anion exchanger and a cation exchanger being packed inside the deionization chamber, characterized in that:

particles containing polyvalent metal are caused to adsorb to at least one surface of the anion exchange membrane, the cation exchange membrane, the anion exchanger, and the cation exchanger, and

a diameter of the particles is at least 0.01 μm but no greater than 100 μm.

14. The electrodeionization device as set forth in any one of claims 11 to 13, wherein the particles are absorbed on the surface of at least one of the anion exchange membrane and the anion exchanger.

15. The electrodeionization device as set forth in any one of claims 11 to 14, wherein at least one of the anion exchange membrane and the cation exchange membrane is a heterogeneous ion exchange membrane.

16. The electrodeionization device as set forth in any one of claims 11 to 15, wherein volume of the particles with respect to volume of the anion exchanger and the cation exchanger is less than 1 volume %.

17. The electrodeionization device as set forth in any one of claims 11 to 16, wherein either one of the anion exchanger and the cation exchanger is packed in said deionization chamber.

18. The electrodeionization device as set forth in any one of claims 11 and 16, wherein the anion exchanger and the cation exchanger are alternately arranged in the deionization chamber along a direction of flow of water in the deionization chamber.

19. The electrodeionization device as set forth in any one of claims 11 to 16, wherein:

the deionization chamber is provided with an intermediate ion exchange membrane that is positioned between the anion exchange membrane and the cation exchange membrane and is partitioned into a first small deionization chamber and second small deionization chamber by the intermediate ion exchange membrane;

at least the anion exchanger is packed in the first small deionization chamber that is partitioned by the anion exchange membrane and the intermediate ion exchange membrane;

at least the cation exchanger is packed in the second small deionization chamber that is partitioned by the cation exchange membrane and the intermediate ion exchange membrane; and

the first small deionization chamber and the second small deionization chamber communicate such that the water to be processed is supplied to one small deionization chamber of the first small deionization chamber and the second small deionization chamber and water that flows out from the one small deionization chamber flows into the other small deionization chamber.

20. The electrodeionization device as set forth in claim 19, wherein the particles are adsorbed to a surface of the intermediate ion exchange membrane.

21. A deionized water manufacturing method that uses the electrodeionization device as set forth in any one of claims 11 to 20, wherein deionized water is obtained by causing water to be processed to flow through the deionization chamber while applying a dc voltage between the anode and the cathode such that current density in the deionization chamber is at least 0.3 A/dm^2 but no greater than 10 A/dm^2.

22. A deionized water manufacturing method that uses an electrodeionization device which is equipped with at least one deionization chamber between an anode chamber provided with an anode and a cathode chamber provided with a cathode and in which the deionization chamber is partitioned by an anion exchange membrane that is positioned on a side facing the anode and a cation exchange membrane that is positioned on a side facing the cathode, at least one of an anion exchanger and a cation exchanger being packed inside the deionization chamber, characterized by comprising steps of:

causing particles that contain polyvalent metal to be adsorbed to a surface of at least one of the anion exchange membrane, the cation exchange membrane, the anion exchanger, and the cation exchanger; and

after the step of causing the adsorption, obtaining deionized water by causing water that is to be processed to flow through the deionization chamber while applying a dc voltage between the anode and the cathode,

wherein the particles are composed of at least one of aluminum silicate, magnesium silicate, calcium silicate, calcium-magnesium silicate, aluminosilicate, and a silicate mineral.

23. A deionized water manufacturing method that uses an electrodeionization device which is equipped with at least one deionization chamber between an anode chamber provided with an anode and a cathode chamber provided with a cathode and in which the deionization chamber is partitioned by an anion exchange membrane that is positioned on a side facing the anode and a cation exchange membrane that is positioned on a side facing the cathode, at least one of an anion exchanger and a cation exchanger being packed inside the deionization chamber, characterized by comprising steps of:

causing particles that contain polyvalent metal to be adsorbed to a surface of at least one of the anion exchange membrane, the cation exchange membrane, the anion exchanger, and the cation exchanger; and

after the step of causing the adsorption, obtaining deionized water by causing water that is to be processed to flow through the deionization chamber while applying a dc voltage between the anode and the cathode,

wherein a diameter of the particles is at least 0.01 μm but no greater than 100 μm.

24. An ion exchange membrane for electrodeionization device, the ion exchange membrane being used in an electrodeionization device which is equipped with at least one deionization chamber between an anode chamber provided with an anode and a cathode chamber provided with a cathode, at least one of an anion exchanger and a cation exchanger being packed inside the deionization chamber, the ion exchange membrane being at least one of an anion exchange membrane that partitions the deionization chamber and that is positioned on a side facing the anode in the deionization chamber, a cation exchange membrane that partitions the deionization chamber and that is positioned on a side facing the cathode in the deionization chamber, and an intermediate ion exchange membrane that further partitions the inside of the deionization chamber into small deionization chambers, the ion exchange membrane characterized in that particles that contain polyvalent metal are caused to be adsorbed to a surface of the ion exchange membrane, and

the particles are composed of at least one of aluminum silicate, magnesium silicate, calcium silicate, calcium-magnesium silicate, aluminosilicate, and a silicate mineral.

25. An ion exchange membrane for electrodeionization device, the ion exchange membrane being used in an electrodeionization device which is equipped with at least one deionization chamber between an anode chamber provided with an anode and a cathode chamber provided with a cathode, at least one of an anion exchanger and a cation exchanger being packed inside the deionization chamber, the ion exchange membrane being at least one of an anion exchange membrane that partitions the deionization chamber and that is positioned on a side facing the anode in the deionization chamber, a cation exchange membrane that partitions the deionization chamber and that is positioned on a side facing the cathode in the deionization chamber, and an intermediate ion exchange membrane that further partitions the inside of the deionization chamber into small deionization chambers, the ion exchange membrane characterized in that

particles that contain polyvalent metal are caused to be adsorbed to a surface of the ion exchange membrane, and

a diameter of the particles is at least 0.01 μm but no greater than 100 μm.

26. An ion exchanger for electrodeionization device, the ion exchanger being used in an electrodeionization device which is equipped with at least one deionization chamber between an anode chamber provided with an anode and a cathode chamber provided with a cathode, the deionization chamber being partitioned by an anion exchange membrane that is positioned on a side facing the anode and a cation exchange membrane that is positioned on a side facing the cathode, the ion exchanger including at least one of anion exchanger and cation exchanger and being packed inside the deionization chamber, the ion exchanger characterized in that:

particles that contain polyvalent metal are caused to be adsorbed to a surface of the ion exchanger, and

the particles are composed of at least one of aluminum silicate, magnesium silicate, calcium silicate, calcium-magnesium silicate, aluminosilicate, and a silicate mineral.

27. An ion exchanger for electrodeionization device, the ion exchanger being used in an electrodeionization device which is equipped with at least one deionization chamber between an anode chamber provided with an anode and a cathode chamber provided with a cathode, the deionization chamber being partitioned by an anion exchange membrane that is positioned on a side facing the anode and a cation exchange membrane that is positioned on a side facing the cathode, the ion exchanger including at

least one of anion exchanger and cation exchanger and being packed inside the deionization chamber, the ion exchanger characterized in that:

particles that contain polyvalent metal are caused to be adsorbed to a surface of the ion exchanger, and

a diameter of the particles is at least 0.01 μm but no greater than 100 μm.