~~Objective of the Invention~~

Summary of the invention

~~The objective~~ Embodiments of the invention ~~is~~ seek to provide an improved treatment device, which is adapted for destructing micro-organisms in a gaseous or liquid medium to be treated, wherein the treatment device is capable of avoiding disadvantages of conventional techniques. In particular, the disadvantages of both conventional destructing and filtering approaches are to be avoided. In particular, ~~the objective~~ embodiments of the invention ~~is~~ also seek to provide a treatment device, which has a reduced complexity, has a high efficiency, does not require additional treatments and/or can be implemented with reduced or without consumption of electrical power. Furthermore, ~~the objective~~ embodiments of the invention ~~is~~ also seek to provide an improved method of treating a gaseous or liquid medium for destructing micro-organisms included in the medium, avoiding disadvantages of conventional techniques.

~~Summary of the Invention~~

~~The above objectives are solved correspondingly with~~ There is disclosed a treatment device and a method of treating a gaseous or liquid medium, comprising the features of the independent claims, respectively. Advantageous embodiments and applications of the invention are defined in the dependent claims.

According to a first aspect of the invention, there is provided a treatment device, which is adapted for destructing micro-organisms in a gaseous or liquid medium to be treated, comprising:
- a treatment substance having an inner hollow structure and being contained in an enclosure accommodating a flow of the medium through the inner hollow structure, wherein
- the inner hollow structure has internal cutting edges which are arranged for destructing the micro-organisms by a mechanical contact of the micro-organisms with the cutting edges of the hollow structure.

According to a second aspect of the invention, there is provided a treatment plant, which is adapted for destructing micro-organisms in a gaseous or liquid medium to be treated, including multiple treatment devices as defined in the first aspect.

According to a third aspect of the invention, there is provided a treatment plant, wherein the treatment devices are coupled in parallel or in series.

According to a fourth aspect of the invention, there is provided a method of treating a gaseous or liquid medium including micro-organisms, wherein a treatment device as defined in the first aspect is used, comprising the steps of:
- flowing the medium through the treatment substance, and
- destructing the micro-organisms by mechanically contacting the micro-organisms with the internal cutting edges of the hollow structure.

~~According to a first general aspect of the invention, the above objective is solved by~~ There is disclosed a treatment device, which is adapted for mechanically destructing (destroying, deactivating) micro-organisms in a gaseous or liquid medium by a mechanical contact of the micro-organisms with a treatment substance. The treatment substance has an inner hollow structure allowing a through-flow of the medium to be treated. Furthermore, the treatment substance is contained in an enclosure

accommodating the treatment substance and accommodating the flow of the medium through the inner hollow structure of the treatment substance. The enclosure is completely or partially filled with the treatment substance. According to the embodiments of the invention, the inner hollow structure of the treatment substance has internal edges (sharp edges), which are arranged for destructing the micro-organisms by the mutual mechanical contact thereof. The internal edges are configured such that micro-organisms flowing with the medium through the treatment substance are destructed, in particular cut, torn and/or punctured by the internal edges. The internal edges are cutting edges, as they have a capability of dissecting (fragmenting, cutting) the micro-organisms.

~~According to a second general aspect of the invention, the above objective is solved by~~ There is also a method of treating a gaseous or liquid medium including micro-organisms, wherein the treatment device ~~according to the above first aspect~~ described above is used. According to embodiments of the invention, the method comprises a step of flowing (pressing) the medium through the treatment substance. Furthermore, the method comprises a step of destructing the micro-organisms by a dissection thereof at the cutting edges of the inner hollow structure of the treatment substance.

Treating the medium generally comprises a destruction of living micro-organisms included in the medium, i. e. changing the micro-organisms such that they are no longer viable, by the mechanical interaction of the micro-organisms with the internal cutting edges of the treatment substance. In particular, the inventive treatment comprises a mechanical disinfection of the water or air. Thus the treatment substance is also called destruction mass.

The inventor has found, that flow forces (shear forces) are created in the medium by flowing it through the hollow structure. In particular by the effect of the enclosure encapsulating the treatment substance, the flow forces have a main direction parallel to the flow direction through the enclosure. Micro-organisms included in the medium hit the cutting edges of the hollow structure, where portions of the micro-organisms, like flagella of bacteria, are cut and/or the cell membrane of the micro-organisms is destroyed. Additionally, the flow forces include turbulent forces, which are created by the effect of the cutting edges. The destructing grinding and milling effect of the edges is enhanced by the turbulent forces. The medium flow has the additional effect that the residual parts of the micro-organisms are carried through the treatment substance, i. e. the treatment substance as such substantially has no filtering effect.

As a main advantage of embodiments of the invention, the micro-organism destruction and thus the removal of potentially living organisms from gaseous or liquid media is obtained by the flow of the medium through the treatment device only. The medium to be treated can be free of chemical substances disintegrating the micro-organisms. The destructing effect of the edges is supported by the inner pressure of micro-organism cells, which can be e. g. 2 at in bacteria. The provision of complex irradiation devices or chemical substances can be avoided. Furthermore, embodiments of the invention does not require an additional shaking or vibrating device for creating flow forces in the medium. Furthermore, the treatment device can be operated with a long-term stability.

As a further advantage, the medium cleaning effect of the treatment device is not restricted to specific micro-organisms, but rather obtainable with any living micro-

Furthermore, the cutting edges preferably have a spike or needle shape and/or a blade shape. Advantageously, the needle shape provides puncture points, while the blade shape can act like a knife. Preferably, the edges, in particular the tips or blade lines thereof, have a radius of curvature below 1 µm, particularly preferred below 0,5 µm.

According to ~~a~~embodiments ~~variant~~ of the invention, the particles of the treatment substance may comprise various materials, i.e. the treatment substance can comprise a mixture of different materials, shapes and/or sizes. Preferably, the particles are made by breaking the respective material, e. g. by crushing glass.

According to embodiments of the invention, the medium to be treated is flown through the treatment device. To this end, the enclosure preferably has at least one input opening, which is adapted for applying the medium with a drive pressure to the treatment device, e. g. for supplying the medium with a pressure above atmospheric pressure. With a preferred example, the input opening is provided with a connector accommodating a tube, hose or funnel guiding the gaseous or liquid medium to be treated.

With a further preferred embodiment of the invention, the treatment device can be provided with a driving device, which is adapted for flowing the medium through the treatment substance, e. g. for applying the drive pressure to the medium. Advantageously, there are no particular requirements with regard to the flow rate. With preferred examples, the flow rate can be selected in a range of 0,1 ml/s to 10 ml/s, in particular 0,3 ml/s to 2 ml/s. Thus, various types of driving devices can be used, which can be selected in dependency on the particular application according to embodiments of the invention. The driving device

ment substance and the residuals of the micro-organisms, in particular for the destroyed micro-organisms. Advantageously, the filtering barrier element provides a final filtering of the medium, thus increasing the cleaning effect of the treatment device.

As a further advantage according to embodiments of the invention, multiple applications of the treatment method are available. According to a preferred application, the medium to be treated comprises water, which is cleaned for providing drinking water. ~~The~~ Embodiments of the invention ~~is~~ are used for hygienic cleaning wastewater treatment. As a particularly important advantage ~~of the invention~~, test experiments of the inventor have proven that by the inventive treatment of water including bacteria the micro-organisms can be removed to a degree that there is no health risk for a person drinking the water. With alternative applications of the embodiments of the invention, ballast water in a ship can be cleaned, or water in a fish farm can be cleaned.

The application of embodiments of the invention is not restricted to liquid media, but also possible with gaseous media. As an example, an air flow of an air conditioning device can be flown through the treatment device for destroying micro-organisms included in the air flow.

Advantageously, the effect of the inventive treatment method can be improved if the medium is repeatedly flown through a treatment substance. A cascade of treatment devices can be provided. The cascade may comprise a parallel and/or serial multistage arrangement of treatment devices, wherein any further treatment device is coupled with the output opening of the enclosure of a foregoing treatment device, and/or a circulation arrangement, wherein the medium is redirected to the input opening of the enclosure after a treatment. The multi-

Claims

1. Treatment device ~~(100)~~, which is adapted for destructing micro-organisms ~~(2)~~ in a gaseous or liquid medium ~~(1)~~ to be treated, comprising:

- a treatment substance ~~(10)~~ having an inner hollow structure and being contained in an enclosure ~~(20)~~ accommodating a flow of the medium ~~(1)~~ through the inner hollow structure, wherein
- the inner hollow structure has internal cutting edges ~~(12)~~ which are arranged for destructing the micro-organisms ~~(2)~~ by a mechanical contact of the micro-organisms ~~(2)~~ with the cutting edges ~~(12)~~ of the hollow structure.

2. Treatment device according to claim 1, wherein

- the treatment substance ~~(10)~~ comprises particles ~~(11)~~ being arranged in the enclosure ~~(20)~~ and having the cutting edges ~~(12)~~.

3. Treatment device according to claim 2, including at least one of the features

- the treatment substance ~~(10)~~ comprises at least one of metal, in particular steel, copper or aluminium, glass, ceramic and diamond particles, and
- the particles ~~(11)~~ have a size above 10 μm, in particular above 20 μm, and/or below 500 μm, in particular below 250 μm.

4. Treatment device according to one of the foregoing claims, including at least one of the features

- the treatment substance ~~(10)~~ has a Mohs hardness of at least 5, in particular at least 6, and

- the treatment substance ~~(10)~~ has a hardness such that the cutting edges ~~(12)~~ have a fixed shape when subjected to the mechanical contact with the micro-organisms ~~(2)~~.

5. Treatment device according to one of the foregoing claims, including at least one of the features
- the cutting edges ~~(12)~~ have at least one shape selected from a needle shape and a blade shape, and
- the cutting edges ~~(12)~~ have a radius of curvature below 1 µm, in particular at below 0,5 µm.

6. Treatment device according to one of the foregoing claims, wherein
- the enclosure ~~(20)~~ has at least one input opening ~~(21)~~, which is configured for applying a drive pressure to the medium to be treated.

7. Treatment device according to claim 6, wherein
- the input opening ~~(21)~~ comprises a connector ~~(22)~~ for connecting the enclosure ~~(20)~~ with a tube ~~(30)~~ guiding the medium ~~(1)~~ to be treated.

8. Treatment device according to one of the foregoing claims, further comprising
- a driving device ~~(40)~~, which is adapted for driving the flow of the medium ~~(1)~~ through the treatment substance ~~(10)~~.

9. Treatment device according to claim 8, wherein the driving device comprises
- a screw conveyor ~~(41)~~,
- a pump device ~~(42)~~,
- a suction device ~~(43)~~, or
- a hydrostatic pressure device ~~(44)~~.

10. Treatment device according to one of the foregoing claims, further comprising at least one of
- a medium container ~~(50)~~ accommodating the medium ~~(1)~~ to be treated and being in fluid communication with the enclosure ~~(10)~~,
- a barrier element ~~(24)~~ arranged at an output opening of the enclosure ~~(20)~~, wherein the barrier element is permeable for the medium ~~(1)~~ to be treated and impermeable for the treatment substance ~~(10)~~.

11. Treatment device according to claim 8, wherein
- the barrier element ~~(24)~~ is impermeable for the destroyed micro-organisms ~~(2)~~, and/or
- the barrier element ~~(24)~~ includes activated carbon.

12. Treatment plant, which is adapted for destructing micro-organisms ~~(2)~~ in a gaseous or liquid medium ~~(1)~~ to be treated, including multiple treatment devices according to one of the foregoing claims.

13. Treatment plant, wherein
- the treatment devices are coupled in parallel or in series.

14. Method of treating a gaseous or liquid medium ~~(1)~~ including micro-organisms ~~(2)~~, wherein a treatment device ~~(100)~~ according to one of the foregoing claims is used, comprising the steps of:
- flowing the medium ~~(1)~~ through the treatment substance ~~(10)~~, and
- destructing the micro-organisms ~~(2)~~ by mechanically contacting the micro-organisms ~~(2)~~ with the internal cutting edges ~~(12)~~ of the hollow structure.

15. Method according to claim 14, including at least one of the features

- the medium ~~(1)~~ is pumped and/or sucked through the treatment substance ~~(10)~~, and
- the medium ~~(1)~~ is flowing through the treatment substance ~~(10)~~ under the effect of gravity.

16. Method according to one of the claims 14 to 15, wherein the treating of the medium ~~(1)~~ comprises at least one of

- cleaning water for providing drinking water,
- cleaning ballast water in a ship,
- cleaning water in a fish farm,
- cleaning an air flow created by an air conditioning device, and
- eliminating bacteria, in particular Escherichia coli and Legionella bacteria, and/or algea from water.

17. Method according to one of the claims 14 to 16, comprising at least one of the steps of

- repeated flowing the medium ~~(1)~~ through the treatment substance ~~(20)~~,
- regenerating the treatment substance ~~(20)~~ by a washing process, and
- filtering the medium ~~(1)~~ before or after flowing the medium ~~(1)~~ through the treatment substance ~~(10)~~.