CLAIMS

1. Carrier element for an aerobic biological water treatment system, the carrier element having

- a first end and a second end at a distance from each other, the maximum diameter of the first end being larger than the maximum diameter of the second end,
- biofilm growing surface structures that extend from the first end to the second end and from inner part of the element towards periphery of the element and,
- at least two support structures that encircle the growing surface structures at the periphery of the element and connect the growing surface structures to each other, the support structures defining the outer boundary surface of the carrier element, whereby the support structures are spaced from each other so that apertures allowing access to the biofilm growing surface structures are formed between the support structures.

2. Carrier element according to claim 1, **characterised** in that the first end has a diameter in the range of 11.0 – 13.6 mm, preferably 11.7 – 13.1 mm, more preferably 12.3 – 12.7 mm.

3. Carrier element according to claim 1 or 2, **characterised** in that the second end has a diameter in the range of 8.5 – 11.3 mm, preferably 9.1 – 10.8 mm, and particularly more preferably 9.4 – 10.5 mm.

4. Carrier element according to any of preceding claims 1 – 3, **characterised** in that the ratio of the diameter of the first end and the diameter of the second end is over 1.2, preferably over 1.25, more preferably over 1.29.

5. Carrier element according to any of preceding claims 1 – 4, **characterised** in that the apertures in the outer boundary surface of the carrier element against the cross sectional area of a similar solid element boundary surface are over 42 %, preferably over 45 %, more preferably over 48 %.

6. Carrier element according to any of preceding claims 1 – 5, **characterised** in that it is made of hard plastic material, such as polyethylene, polypropylene or their mixture.

7. Carrier element according to any of preceding claims 1 – 6, **characterised** in that it is conical in shape and/or the cross-sections of the first and second ends are circular.

8. Carrier element according to any of preceding claims 1 – 7, **characterised** in that the length of the carrier element, measured from the first end to the second end, is 11.0 – 14.9 mm, preferably 11.6 – 13.8 mm, more preferably 12.2 – 12.7 mm.

9. Carrier element according to any of preceding claims 1 – 8, **characterised** in that it is made by injection moulding.

10. Biological water treatment system comprising a treatment reactor, which has a reactor volume defined by reactor wall(s) and bottom, which reactor volume comprises freely moving carrier elements according any of claims 1 to 9.

11. Biological water treatment system according to claim 10, **characterised** in that the filling degree of carrier elements in the reactor is between 14 – 28 volume-%, preferably 16 – 26 volume-%, more preferably 18 – 25 volume-%, still more preferably 20 – 25 volume-% of the total reactor volume.

12. Biological water treatment system according to claim 10 or 11, **characterised** in that the reactor comprises a bottom aeration system comprising one or more grid-like aeration elements.

13. Biological water treatment system according to claim 12, **characterised** in that the grid-like aeration elements comprise a main air feed pipe and a number of air diffusers arranged perpendicularly to the air feed pipe.

14. Biological water treatment system according to claim 12 or 13, **characterised** in that the aeration elements comprise one or several air diffusers that are made of plastic material.

15. Biological water treatment system according to any of claims 12 – 14, **characterised** in that the aeration system is arranged self-flushing.

16. Biological water treatment system according to any of preceding claims 10 – 15, **characterised** in that it comprises two or more treatment reactors arranged in parallel or in series.

17. Biological water treatment system according to any of preceding claims 10 – 16, **characterised** in that it comprises a clarifier, such as a gravity settler, dissolved air flotation (DAF) or lamella clarifier, arranged after the treatment reactor and connections for recycling sludge from clarifier back to treatment reactor.

18. Biological water treatment system according to claim 17, **characterised** in that in the upper part of the treatment reactor is arranged an output connection, which is connected to the clarifier.

19. Biological water treatment system according to claim 17 or 18, **characterised** in that it comprises an activated sludge process arranged between the treatment reactor and the clarifier.

20. Biological water treatment system according to any of preceding claims 10 – 19, **characterised** in that it comprises an oxygen sensor that is arranged in connection with the treatment reactor to measure oxygen concentration in the reactor and an adjustment means for adjusting the aeration of the reactor according to the measured oxygen concentration.

21. Use of a carrier element according to any of claims 1 – 9 or a biological water treatment system according to any of claims 10 – 20 for treating or purifying waste

water from petrochemical industry, food and/or beverage industry or for treating or purifying municipal waste water.

22. Use of a carrier element according to any of claims 1 – 9 or a biological water treatment system according to any of claims 10 – 20 for treating or purifying waste water having a value for the chemical oxygen demand (COD) of at least 200 mg/l, more typically 300 – 4000 mg/l, most typically 400 – 2000 mg/l.

23. Method for biologically treating waste water by
- leading water to be treated or purified to a treatment reactor comprising carrier elements which are freely moving, suspended in the water, in the treatment reactor and on which a biofilm is grown,
- feeding air or oxygen to the treatment reactor, and
- leading treated or purified water away from the treatment reactor,

characterised in using carrier elements according any of the claims 1 to 9 in the treatment reactor.

24. Method according to claim 23, **characterised** in leading treated or purified water to a clarifier, and recycling sludge from the clarifier back to treatment reactor.

25. Method according to claim 24, **characterised** in that the volume of the recycled sludge flow is 2 – 15 volume-%, preferably 3 – 12 volume-%, more preferably 5 – 10 volume-% of the incoming flow of water to be treated or purified.

26. Method according to any of claims 23 – 25, **characterised** in leading treated or purified water away from the upper part of the treatment reactor

27. Method according to any of claims 23 – 26, **characterised** in bringing the carrier elements in a counterclockwise rotation against the incoming feed flow in the treatment reactor.

CLAIMS

1. Carrier element for an aerobic biological water treatment system, the carrier element having

- a first end and a second end at a distance from each other, the maximum diameter of the first end being larger than the maximum diameter of the second end so that the carrier element is conical in shape,
- a length of the carrier element, measured from the first end to the second end, being 11.0 – 14.9 mm,
- biofilm growing surface structures, which are internal walls that extend from the first end to the second end and from an inner part of the element towards a periphery of the element, the carrier element comprising a solid longitudinal central axis to which the internal walls are attached, and,
- at least two support structures that encircle the growing surface structures at the periphery of the element and connect the growing surface structures to each other, the support structures defining an outer boundary surface of the carrier element, whereby the support structures are spaced from each other so that apertures allowing access to the biofilm growing surface structures are formed between the support structures, the apertures in the outer boundary surface of the carrier element against a cross sectional area of a similar solid element boundary surface being over 42 %.

2. Carrier element according to claim 1, wherein the first end has a diameter in a range selected from one of: 11.0 – 13.6 mm; 11.7 – 13.1 mm; and 12.3 – 12.7 mm.

3. Carrier element according to claim 1 or 2, wherein the second end has a diameter in a range selected from one of: 8.5 – 11.3 mm; 9.1 – 10.8 mm; and 9.4 – 10.5 mm.

4. Carrier element according to any one of preceding claims 1 – 3, wherein a ratio of the diameter of the first end and the diameter of the second end is one of the following: over 1.2; over 1.25; and over 1.29.

5. Carrier element according to any one of preceding claims 1 – 4, wherein the apertures in the outer boundary surface of the carrier element against the cross sectional area of the similar solid element boundary surface are either: over 45 %, or over 48 %.

6. Carrier element according to any one of preceding claims 1 – 5, wherein the carrier element is made of hard plastics material.

7. Carrier element according to claim 6 wherein the hard plastics material is one of: polyethylene; polypropylene; and a mixture of polyethylene and polypropylene.

8. Carrier element according to any one of preceding claims 1 – 7, wherein cross-sections of the first and second ends are circular.

9. Carrier element according to any one of preceding claims 1 – 8, wherein the length of the carrier element, measured from the first end to the second end, is in a range selected from one of: 11.6 – 13.8 mm; and 12.2 – 12.7 mm.

10. Carrier element according to any one of preceding claims 1 – 9, wherein the carrier element is made by injection moulding.

11. Biological water treatment system comprising a treatment reactor, which has a reactor volume defined by reactor wall(s) and bottom, which reactor volume comprises one or more freely moving carrier elements according any one of claims 1 to 10.

12. Biological water treatment system according to claim 11, wherein a filling degree of carrier elements in the reactor according to percentage of total reactor volume is in one of ranges: 14 – 28 volume-%; 16 – 26 volume-%; 18 – 25 volume-%; and 20 – 25 volume-%.

13. Biological water treatment system according to claims 11 or 12, wherein the reactor comprises a bottom aeration system comprising one or more grid-like aeration elements.

14. Biological water treatment system according to claim 13, wherein the grid-like aeration elements comprise a main air feed pipe and a number of air diffusers arranged perpendicularly to the air feed pipe.

15. Biological water treatment system according to claim 13 or 14, wherein the aeration elements comprise one or several air diffusers that are made of plastics material.

16. Biological water treatment system according to any one of claims 13 – 15, wherein the aeration system is arranged to be self-flushing.

17. Biological water treatment system according to any one of preceding claims 11 – 16, wherein the reactor is one of two or more treatment reactors arranged in parallel or in series with each other.

18. Biological water treatment system according to any one of preceding claims 11 –17, comprising: a clarifier in fluid communication with the treatment reactor; and arranged to recycle sludge from clarifier back to treatment reactor.

19. Biological water treatment system according to claim 18 wherein the clarifier is one of: a gravity settler; a dissolved air flotation (DAF) device; and a lamella clarifier.

20. Biological water treatment system according to claim 18 or 19, wherein an upper part of the treatment reactor is arranged an output connection, which is connected to the clarifier.

21. Biological water treatment system according to any one of claims 18 – 20, comprising an activated sludge process arranged between the treatment reactor and the clarifier.

22. Biological water treatment system according to any one of preceding claims 11 – 21, comprising an oxygen sensor that is arranged to measure oxygen concentration in the reactor and an adjustment means for adjusting the aeration of the reactor according to the measured oxygen concentration.

23. Use of a carrier element according to any one of claims 1 – 10 or a biological water treatment system according to any one of claims 11 – 22 for treating or purifying waste water from petrochemical industry, food and/or beverage industry or for treating or purifying municipal waste water.

24. Use of a carrier element according to any of claims 1 – 10 or a biological water treatment system according to any of claims 11 – 22 for treating or purifying waste water having a chemical oxygen demand (COD) value in a range selected from one of: at least 200 mg/l; 300 – 4000 mg/l; and 400 – 2000 mg/l.

25. Method for biologically treating waste water using one or more carrier elements according any one of the claims 1 to 9 in the treatment reactor comprising:
- leading water to be treated or purified to a treatment reactor comprising the one or more carrier elements which are freely moving, suspended in the water, in the treatment reactor and on which a biofilm is grown,
- feeding air or oxygen to the treatment reactor, and
- leading treated or purified water away from the treatment reactor.

26. Method according to claim 25, comprising leading treated or purified water to a clarifier, and recycling sludge from the clarifier back to the treatment reactor.

27. Method according to claim 24, wherein a volume of recycled sludge as a percentage of an incoming flow of water to be treated or purified is in a range selected from one of: 2 – 15 volume-%, 3 – 12 volume-%, and 5 – 10 volume-%.

28. Method according to any of claims 25 – 27, comprising leading treated or purified water away from an upper part of the treatment reactor

29. Method according to any one of claims 25 – 28, comprising bringing the one or more carrier elements in a rotational direction against the incoming flow in the treatment reactor.