Claims

1. A method for the treatment of wastewater in a biological treatment reactor, comprising the steps of:

   (a) introducing wastewater influent at the bottom part of the reactor while simultaneously decanting treated wastewater effluent at the operational water level in the top part of the reactor;

   (b) an aeration step; and

   (c) a settling step wherein the biomass is allowed to settle;

wherein step (a) is performed under vertical plug flow conditions achieved by introducing the wastewater influent into the reactor through an influent distributor system comprising ~~one~~ two or more distributor pipes, said ~~one~~ two or more pipes comprising one or more nozzle outlets, preferably directed downwards, arranged to provide an equal distribution of influent wastewater across the reactor bottom surface, and discharging the treated wastewater effluent through an effluent decanter system configured to discharge the treated wastewater effluent equally across the operational water level in the top part of the reactor;

and wherein during step (a) the equal distribution of the influent wastewater across the distributor pipes and/or the degree of plug-flow in the reactor is monitored, and when a suboptimal distribution or a suboptimal degree of plug-flow is detected the influent distributor system and/or effluent decanter system is cleaned by removing fouling and/or blockage~~.~~,

wherein in step (a) preferably a vertical vent pipe is connected to each distributor pipe, the vertical vent pipe ending above the operational water level of the reactor in order to release air or oxygen entrained in the distributor pipe, and

wherein a distributor pipe of the influent distributor system is cleaned by entering, at the reactor top, a high-pressure lance, or alternative mechanical or hydromechanical device, through the vent pipe connected to the distributor pipe.

~~2. Method according to claim 1, wherein the influent distributor system comprises two or more distributor pipes, connected to a common manifold or header.~~

~~3~~2. The ~~Method~~ method according to claim 1 ~~or claim 2~~, wherein the influent distributor system is cleaned by:

   (i) draining the reactor and cleaning one or more of the distributor pipes and their nozzles manually; or

   (ii) lifting up one or more of the distributor pipes for manual clean; or

   (iii) inserting an in-pipe cleaning device, for example a pipe pig, cleaning robot or hydrojet, into the header; or

   (iv) temporarily increasing the flow through the influent distributor system.

~~4. Method according to claim 1 or claim 2, wherein in step (a) a vertical vent pipe is connected to each distributor pipe, the vertical vent pipe ending above the operational water level of the reactor in order to release air or oxygen entrained in the distributor pipe.~~

~~5. Method according to claim 4, wherein a distributor pipe of the influent distributor system is cleaned by entering, at the reactor top, a high-pressure lance, or alternative mechanical or hydromechanical device, through the vent pipe connected to the distributor pipe.~~

~~6~~3. The ~~Method~~ method according to any of the preceding claims, wherein a grid with header is routed above water level, optionally with an entry for a cleaning device located in the header.

~~7~~4. The ~~Method~~ method according to any of the preceding claims, wherein during step (a) the degree of plug-flow in the reactor is monitored by determining the profile of a suitable parameter across the reactor from the bottom part to the top part of the reactor, at various times during step (a).

~~8~~5. The ~~Method~~ method according to claim ~~7~~4, wherein the suitable parameter is the concentration of a pollutant, preferably chemical oxygen demand (COD), ammonium or phosphate, turbidity, pH, redox potential, conductivity or temperature.

~~9. Method according to any one of claims 1 – 3 and 6 – 8, wherein in step (a) the equal distribution of wastewater influent across the distributor pipes is monitored through measurement of flow and/or pressure in two or more distributor pipes.~~

~~10~~6. The ~~Method~~ method according to any one of the preceding claims~~claims 4 – 8~~, wherein in step (a) the equal distribution of wastewater influent across the distributor pipes is monitored by measuring water level and/or pressure and/or temperature or other suitable parameter in the vent pipes.

~~11~~7. The ~~Method~~ method according to any one of the preceding claims, wherein in step (a) the equal distribution of the wastewater influent across the distributor pipes results in a degree of plug-flow that enables that a minimum of 30%, preferably more than 50%, more than 60% or more than 70%, of the reactor volume is displaced towards the treated wastewater effluent decanter system without significant breakthrough of untreated wastewater.

~~12~~8. The ~~Method~~ method according to any one of the preceding claims, wherein more than 70% of the biomass particles in the reactor have a diameter ≥ 0.2 mm, preferably a diameter in the range of 0.2 – 5.0 mm.

~~13~~9. The ~~Method~~ method according to any one of claims 1 – ~~11~~7, wherein more than 70% of the biomass particles in the reactor have a diameter of ≤ 0.2 mm.

~~14~~10. A ~~Liquid~~ liquid distributor system comprising ~~one~~ two or more distributor pipes, said ~~one~~ two or more pipes comprising one or more nozzle outlets arranged to provide an equal distribution of influent wastewater across the reactor bottom surface, wherein a vertical vent pipe is connected to each distributor pipe.

~~15. Liquid distributor system according to claim 14, comprising two or more distributor pipes.~~

~~16. Liquid distributor system according to claim 14 or claim 15, wherein each distributor pipe comprises two or more nozzle outlets.~~

~~17. Liquid distributor system according to any one of claims 14 – 16, wherein the one or more nozzle outlets are directed downwards.~~

~~18. Liquid distributor system according to any one of claims clam 14 – 17, wherein the distance between nozzle outlets in a distributor pipe is in the range of 0.5 to 10 m.~~

~~19. Liquid distributor system according to any one of claims clam 14 – 18, wherein each distributor pipe is connected to a distributor pipe manifold.~~

~~20. Liquid distributor system according to any one of claims clam 14 – 19, wherein each vent pipe is equipped with a removable endcap with vertical positioned opening, or with a U-type bend with open end.~~

~~21. Liquid distributor system according to any one of claims clam 14 – 20, wherein each vent pipe is equipped with a water level meter, a pressure meter and/or a temperature sensor, preferably a distribution temperature sensing (DTS) cable.~~

~~22~~11. Use of the liquid distributor system according to ~~any one of~~ claim~~s~~ ~~14 – 21~~10 in a method for the aerobic treatment of wastewater in a vertical plug flow (VPF) biological treatment reactor.

~~23~~12. Use according to claim ~~22~~11, wherein the method for the treatment of wastewater is according to any one of claims 1 – ~~13~~9.

~~24~~13. An installation for carrying out the process according to any one of claims 1 – ~~13~~9, comprising a reactor with a liquid inlet system at the bottom part of the reactor, a liquid outlet system at the top of the reactor and a gas inlet at the bottom of the reactor, wherein the liquid inlet system comprises ~~one~~ two or more distributor pipes, said ~~one~~ two or more pipes each

comprising one or more nozzle outlets arranged to provide an equal distribution of liquid across the reactor bottom surface, wherein a vertical vent pipe is connected to each distributor pipe, the vertical vent pipe ending above the operational water level of the reactor in order to release air entrained in the distributor pipe.

~~25. Installation according to claim 24, wherein the liquid inlet system comprises two or more distributor pipes.~~

~~26. Installation according to claim 24 or claim 25, wherein each distributor pipe of the liquid inlet system comprises two or more nozzle outlets.~~

~~27. Installation according to any one of claims 24 – 26, wherein the one or more nozzle outlets in each distributor pipe are directed downwards.~~

~~28. Installation according to any one of claims clam 24 – 27, wherein the distance between nozzle outlets in a distributor pipe is in the range of 0.5 to 10 m, and/or wherein there are 0.5 to 50 nozzle outlets per m^2 of the reactor bottom surface.~~

~~29. Installation according to any one of claims clam 24 – 28, wherein each distributor pipe is connected to a distributor pipe manifold.~~

~~30. Installation according to any one of claims clam 24 – 29, wherein each vent pipe is equipped with a removable endcap with vertical positioned opening, or with a U-type bend with open end.~~

~~31. Installation according to any one of claims clam 24 – 30, wherein each vent pipe is equipped with a water level meter, a pressure meter and/or a temperature sensor, preferably a distribution temperature sensing (DTS) cable.~~

~~32. Installation according to any one of claims 24 – 31, wherein the installation further comprises means for the determination of the profile of a suitable parameter across the reactor from the bottom part to the top part of the reactor.~~

~~33. Installation according to claim 32, wherein the suitable parameter is the concentration of a pollutant, turbidity, pH, redox potential, conductivity or temperature.~~

~~34. Installation according to claim 32 or 33, wherein said installation comprises analyzers or probes for determining the concentration of a pollutant, turbidity, pH, redox potential, conductivity and/or temperature.~~

~~35~~14. Use of the installation according to ~~any one of~~ claim~~s~~ ~~24 – 34~~13 in the aerobic treatment of wastewater in a vertical plug flow (VPF) biological treatment reactor~~.~~.

~~36. Use according to claim 35,~~ wherein the method for the treatment of wastewater is preferably according to any one of claims 1 – ~~13~~9.