

Claims

1. Method for treating an aqueous fluid comprising a biodegradable organic substance in an installation comprising an upflow bioreactor (1) containing a sludge bed, said sludge bed comprising biomass and an external separator (2), wherein the method comprises
 - 5 - feeding the aqueous fluid into a lower part of the bioreactor, contacting the fed fluid with the biomass, thereby forming biogas from the biodegradable organic substance;
 - withdrawing the fluid that has been contacted with the biomass from an upper part of the bioreactor, which withdrawn fluid comprises biomass;
 - 10 - feeding the fluid comprising the biomass withdrawn from the upper part of the bioreactor into the external separator (2) comprising a separation chamber, preferably provided with tilted internals, wherein the fluid comprising the biomass is separated into a liquid phase, which has a reduced biomass content or is essentially free of biomass, and a fluid phase enriched in biomass;
 - 15 - subjecting fluid phase enriched in biomass to a density reduction downstream of the external separator; and
 - returning the fluid enriched in biomass which has been subjected to a density reduction to the bioreactor.
2. Method according to claim 1, wherein the bioreactor has a headspace,
 - 20 biogas is taken from the headspace of the bioreactor and introduced into said fluid phase enriched in biomass downstream of the external separator, thereby reducing the density of said fluid enriched in biomass downstream of the external separator.
3. Method according to claim 1 or 2, wherein an external gas is introduced in said fluid phase enriched in biomass downstream of the external separator,
 - 25 thereby reducing the density of said fluid enriched in biomass downstream of the external separator, which gas preferably is nitrogen.
4. Method according to claim 1, 2 or 3, wherein a (pressurized) liquefied gas or a (pressurized) gas dissolved in a liquid phase is introduced in said fluid phase enriched in biomass downstream of the external separator, which liquefied
 - 30 gas or dissolved gas expands (evaporated) thereby reducing the density of said fluid phase enriched in biomass downstream of the external separator.

5. Method according to claim 3 or 4, wherein said fluid enriched in biomass which has been subjected to a density reduction is fed into a gas-fluid separator (50), wherein the fluid is separated into a gas phase and a fluid phase comprising biomass, and wherein said fluid phase comprising biomass is returned to the
5 bioreactor (1).
6. Method according to claim 5, wherein the gas-fluid separator (50) is a gas-liquid separator, an air stripper or a gas separator drum.
7. Method for treating an aqueous fluid comprising a biodegradable organic substance, optionally according to any of the preceding claims, in an
10 installation comprising an upflow bioreactor (1) containing a sludge bed, said sludge bed comprising biomass and an external separator (2), wherein the method comprises
- feeding the aqueous fluid into a lower part of the bioreactor, contacting the fed fluid with the biomass, thereby forming biogas from the biodegradable organic
15 substance;
 - withdrawing the fluid that has been contacted with the biomass from an upper part of the bioreactor, which withdrawn fluid comprises biomass;
 - feeding the aqueous fluid comprising the biomass withdrawn from the upper part of the bioreactor into the external separator (2) comprising a separation chamber
20 provided with tilted internals wherein the aqueous fluid comprising the biomass is separated into a liquid phase, which has a reduced biomass content or is essentially free of biomass, and a fluid phase enriched in biomass; and
 - returning said fluid phase enriched in biomass from the external separator to the bioreactor via a venturi-injector (42) having a higher pressure inlet, a lower
25 pressure outlet and a suction inlet, wherein aqueous fluid comprising a biodegradable substance to be treated in bioreactor enters the venturi-injector via said higher pressure inlet, the fluid phase enriched in biomass from the external separator enters the venturi-injector via said suction inlet and said fluid phase enriched in biomass, said aqueous fluid to be treated in the bioreactor leave the
30 venturi-injector together via the lower pressure outlet and are fed to the bioreactor.
8. Method according to any of the preceding claims, wherein the density of said fluid phase enriched in biomass is reduced downstream of the external separator by at least 10 %, in particular by 20-95 %, and preferably to a density in

the range of 10-900 kg/m³, more preferably to a density in the range of 100-800 kg/m³.

9. Method according to any of the preceding claims, wherein the installation comprises a conditioning tank (12) into which the aqueous fluid to be treated in the bioreactor (1) is fed, from which conditioning tank (12) the aqueous fluid is fed to the bioreactor (1) and wherein a part of the liquid phase having a reduced biomass content or being essentially free of biomass is fed from the external separator (2) to said conditioning tank (12), in which conditioning tank the aqueous fluid preferably is subjected to a treatment comprising
- 10 - maintaining the pH of the aqueous fluid in the conditioning tank at or adjusting the pH of the aqueous fluid in the conditioning tank to a pH in the range of 6.0 to 7.5 and/or
- maintaining the temperature of the aqueous fluid in the conditioning tank at or adjusting the temperature of the aqueous fluid in the conditioning tank to a temperature in the range of 20 to 55 °C, in particular in the range of 30-40 °C.
10. Method according to any of the preceding claims, wherein the bioreactor comprises a granular sludge bed (GSB), which GSB comprises anaerobic microorganisms and wherein the biodegradable organic substance is converted by the anaerobic micro-organisms, thereby forming the biogas.
- 20 11. Method according to any of the preceding claims, wherein the fluid that is withdrawn from the upper part of the bioreactor comprises granular biomass, wherein granular biomass settles inside the external separator (2), and wherein the fluid phase that is returned to the bioreactor (1) comprises settled granular biomass.
- 25 12. Method according to any of the preceding claims, wherein the external separator (2) is placed lower than the inlet (5) withdrawing aqueous fluid from the bioreactor (1) of the feed conduit (6) feeding said fluid to the external separator.
13. Installation for microbiologically treating an aqueous fluid comprising a biodegradable organic substance, wherein the installation comprises
- 30 - a bioreactor (1), preferably an upflow granular sludge bed reactor, more preferably an expanded granular sludge bed reactor, the bioreactor comprising an outlet for biogas;
- an external separator (2) comprising a separation chamber, preferably provided with tilted internals, arranged to separate a liquid phase from a fluid phase

comprising biomass, the external separator comprising an inlet (4) for an aqueous fluid connected to an inlet (5) of a conduit (6) for withdrawing an aqueous fluid from bioreactor (1), an outlet (7a) for aqueous fluid, an outlet (8) for a fluid enriched in biomass to an inlet (9) for the fluid enriched in biomass into the
5 bioreactor (1) via a conduit (10); and

- at least one injector selected from the group consisting of

- (a) injectors configured to inject a fluid medium, such as a gas or a (pressurized) liquid into the fluid enriched in biomass downstream of the external separator and
- 10 (b) venturi-injectors configured to return fluid enriched in biomass from the external separator to the bioreactor.

14. Installation according to claim 13, wherein the bioreactor (1) has a headspace, and a conduit providing a flow path for biogas from said headspace to said injector configured to inject a fluid medium, and which injector is preferably
15 situated in the conduit (10) for returning a mixture of the fluid phase enriched in biomass and the biogas that has been injected in said fluid phase.

15. Installation according to claim 13 or 14, wherein said injector configured to inject a fluid medium is connected to an external gas source, an external liquefied gas source or an external dissolved gas source.

20 16. Installation according to claim 15, wherein the conduit (10) between outlet (8) for a fluid enriched in biomass of the external separator and inlet (9) for returning the fluid enriched in biomass into the bioreactor (1) is provided with an outlet (52) connected to an inlet (51) of a fluid-gas separator (50) arranged to separate a gas phase from a fluid phase comprising biomass, wherein said fluid-gas
25 separator (50) is provided with an outlet (53) configured to discharge gas from the gas-fluid separator and an outlet (54) configured to discharge a fluid comprising biomass into the bioreactor, which outlet (54) configured to discharge the fluid comprising biomass into the bioreactor is at a higher height than the injector configured to inject a fluid medium, and which outlet (54) configured to discharge
30 the fluid comprising biomass into the bioreactor preferably is in a middle or lower part of the bioreactor.

17. Installation according to claim 16, wherein the fluid-gas separator (50) is arranged relative to the bioreactor (1) such that, during use, the fluid level inside

the fluid-gas separator (50) is at a higher level than the fluid level inside the bioreactor (1).

18. Installation according to any of the claims 13-15, wherein the conduit (10) for returning a mixture of gas and the fluid enriched in biomass is provided with an outlet (9) configured to discharge the returned mixture into the bioreactor, which outlet (9) configured to discharge the returned mixture into the bioreactor is at a higher height than the biogas injector (23), and which outlet (9) configured to discharge the returned mixture into the bioreactor preferably is in a middle or lower part of the bioreactor.

19. Installation according to any of the claims 13-18, comprising a conditioning tank (12) for pretreating the aqueous fluid, comprising an inlet for wastewater (13), an outlet for the aqueous fluid (14) connected to an inlet (15) of the bioreactor via a conduit (16) a return line (37) for liquid phase from the external separator (2) to the conditioning tank (12), and an outlet for biogas.

20. Installation according to any of the claims 13-19, wherein the bioreactor (1) comprises an internal biogas collector (22) positioned at a height whereby the biogas collector, at least during use of the installation, is submerged in the sludge bed in the bioreactor, which biogas collector is connected to a biogas injector (23) configured to inject biogas into the conduit (10) for returning the fluid enriched in solids from the external separator (2) to the bioreactor (1).

21. Installation according to any of the claims 13-20, wherein the external separator is positioned at about the same height or below the bottom of the bioreactor, in particular on a floor.

22. Installation according to any of the claims 13-21, wherein the installation comprises a feed conduit (34) configured to feed aqueous fluid comprising solids from the bioreactor (1) into the external separator (2), wherein the feed conduit (34) has an inlet (35) located above a deflector or baffle (36) present in the bioreactor (1), which deflector or baffle is configured to direct aqueous fluid comprising solids present in the bioreactor (1) into the external feed conduit (34).

23. Installation according to any of the claims 13-22, wherein the external separator (2) comprises a separation chamber provided with a modular tilted-internals unit and a sealable and openable entry configured to allow replacement of the modular tilted-internals unit.

24. Installation according to claim 23, wherein the separation chamber is an at least substantially round-cylindrical separation chamber, which is –during use – positioned essentially horizontally (i.e. its radial axis is essentially horizontal), in which separation chamber – at least when in use - a replaceable module (102e) comprising tilted separation internals is present at least substantially along the separation chamber's radial axis, and which separation chamber has at least one base side (102a, 102b) which is sealable and openable to provide an opening adapted to allow placement of the module comprising tilted separation internals into its working position and removing it from its working position.