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(71) Applicant (*for all designated States except US*): ECO FLANDERS [BE/BE]; Esenweg 116, B-8600 Esen (BE).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): MEERS, Erik [BE/BE]; Tempel 19, B-9572 Sint-Martens-Lierde (BE). CHRISTIAENS, Patrick [BE/BE]; Tiengemeten 15, B-8730 Beernem (BE). VAN BELLE, Freek [BE/BE]; Hovenierstraat 1, B-8750 Zwevezele (BE).

(74) Agents: LEHERTE, Georges et al.; Gevers & Vander Haeghen, Holidaystraat 5, B-1831 Diegem (BE).

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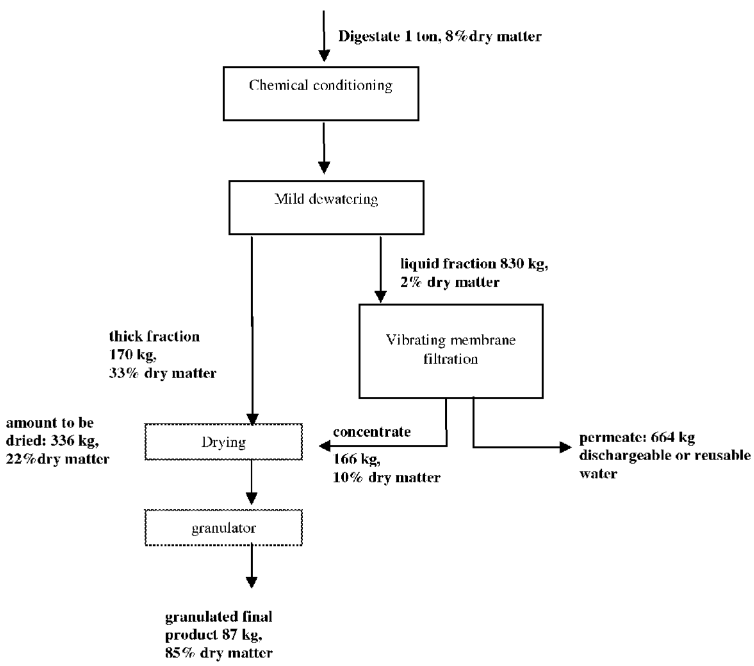
(54) Title: IMPROVED SEPARATION/PURIFICATION METHOD / INSTALLATION FOR AQUEOUS LIQUID DISPERSIONS OF ORGANIC MATERIAL, AND USE OF SUCH METHOD / INSTALLATION IN AN INTEGRATED TREATMENT OF MANURE AND/OR ORGANIC DIGESTATES

Fig. 1



(57) Abstract: The invention relates to a method for separating an aqueous liquid dispersion of organic material into a concentrated solid fraction and a solid poor liquid fraction, by a preliminary mechanical separation operation and subsequent membrane filtration, whereas the preliminary mechanical separation comprises at least one mild dewatehng operation and the subsequent membrane filtration consists of vibrating membrane filtration. The invention also relates to a separation installation suitable for such method, to a global method for the treatment of organic waste involving such method and to an integrated treatment installation for the global organic waste treatment method.

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Improved separation/purification method / installation for aqueous liquid dispersions of organic material, and use of such method / installation in an integrated treatment of manure and/or organic digestates.

The invention relates to the separation of aqueous liquid dispersions of organic material, hereinafter referred to as "organic dispersion", such as manure and/or so called 'digestates' / digestion products resulting from the bio-fermentation of organic waste materials, into a solid fraction on the one hand and an aqueous fraction on the other hand, and to globally cost and energy effective methods for disposal of such organic dispersions.

The invention aims in particular at providing a cost-effective treatment method / installation for manure, combining proper treatment technology with drying and water treatment filtration.
The most important feature of bio-methanization / bio-fermentation is that by means of co- fermentation of manure and/or organic waste streams, and of energy plants so called "green electricity" is produced, whereas, simultaneously, an important amount of thermal energy becomes available that can be used for the end-treatment of the bio-fermentation digestate involving drying and pasteurisation.

Research showed however that the surplus of heat of existing cogeneration installations is totally insufficient to dry digestate from such installations in its totality.

The invention results from a research program for an improved, more efficient combination of dewatering (separation and membrane filtration) and evaporation.

In order to obtain adequate performance regarding exclusion of mineral and organic constituents of the liquid phase, with the membrane filtration, a preliminary adequate separation of the digestate is required.

Summary of the invention

The separation method / installation according to the invention aims at delivering a solid fraction with a high dry matter quality and a pasteurised liquid fraction with a very low dry matter quality using the filtration unit.
In this way also the drying method / installation improves.
A detail study of the energy balance proves clearly that the remaining heat of the cogeneration engine can thus have enough energetic power to dry and pasteurise the end product, after separation and membrane filtration.

The key of the invention is the specific selection / synergetic combination of different elements for the separation method according to the invention (in particular to be implemented in what is called the "end treatment" or "after treatment" of a bio-fermentation process), to be integrated in a single system, involving separator, dryer and water filtration, all fuelled by the same biogas engine.

The invention there for provides a method for separating an aqueous liquid dispersion of organic material into a concentrated solid fraction and a solid poor liquid fraction, comprising an optional coagulation and flocculation operation, a preliminary mechanical separation operation and subsequent membrane filtration, in which method the preliminary mechanical separation more specifically comprises at least one mild dewatering operation and the subsequent membrane filtration specifically consists of vibrating membrane filtration.

The expression "mild dewatering" as used in the present context refers to a mechanical separation operation in essence only involving (mere) gravitational draining, without substantial external pressure, in particular such essentially mere gravitational drainage involving the use of filter cloth. The expression "mild dewatering" thus specifically distinguishes from operations such as centrifugation and screw press operations, as well as from operations such as decantation, which does not involve actual physical separation of the liquid ("dewatering").

The expression "coagulation and flocculation" as used here should be understood in a rather broad sense, involving chemical coagulation (for instance by means of Fe^{3+} ions) and flocculation by means of flocculent polymers). The coagulation-flocculation process induces aggregation of suspended solids into larger "flocs", which facilitates their removal from the aqueous phase. Separation after coagulation-flocculation therefore results in liquid fraction poor in suspended solids.

As stated above the key of the invention resides in the specific selection / synergetic combination of a preliminary mechanical separation based on a mild dewatering operation and of a subsequent filtration based on vibrating membrane filtration.

Although more or less similar principles have been experimented in state of the art approaches, it should be stressed that the proposed selection / combination of specific features appears to be the first ever development able to avoid the problems of clogging of, and (bio)fouling on, filtration membranes, in the specific context of the treatment aqueous liquid dispersions of organic material such as manure and fermentation digestates, and of integrated bio fermentation processes / installations.

According to a preferred feature of the invention the membrane filtration more particularly consists of vibrating reversed osmosis membrane filtration.

In a specific embodiment of the invention a coagulation and flocculation operation is preferably applied to the aqueous liquid dispersion of organic material before the mild dewatering operation is applied.

According to another preferred feature of the invention the mild dewatering operation is selected from a straining-belt / belt-sieve operation, a thickening table operation, a rotating drum filter / rotating drum sieve operation, a sieve bend / barred grate / perforated bend / barred sieve operation, or a successively belt-sieve and rotating drum filter operation.

Most preferably the mild dewatering operation is a separation operation by means of a rotating drum filter, dividing the incoming sludge in a liquid fraction relatively poor in suspended solids (preferably < 2% dry matter) and a solid fraction enriched with the incoming sludge's solids.

The expression "rotating drum filter" as used in this context refers to a liquid filter of the type comprising a cloth filter media in the form of a drum. Sludge flows into the interior of the drum thence radially outwardly through the cloth filter media as the filter rotates around it's cylindrical axis. The filter cloth is periodically backwashed by pressurized water in the reverse direction of filtration. Dewatered sludge leaves the drum at the opposing end of the cylinder.

According to still another preferred feature of the invention the aqueous liquid dispersion of organic material may be, specifically, manure, a fermentation digestate thereof, a fermentation digestate of any kind of organic dispersion, or a mixture of several of those.

The invention also specifically provides an installation for separating an aqueous liquid dispersion of organic material into a concentrated solid fraction and a solid poor liquid fraction, comprising a mechanical primary separator and a subsequent membrane filtration unit, in which installation the preliminary mechanical separator specifically comprises at least one mild dewatering separator and the subsequent membrane filtration unit specifically consists of a vibrating membrane filtration unit.

In a preferred embodiment of the installation according to the invention the membrane filtration unit suitably consists of a vibrating reversed osmosis membrane filtration unit.

According to another preferred embodiment of the installation according to the invention the mild dewatering separator is very appropriately selected from a straining-belt / belt-sieve, a thickening table, a rotating drum filter, a sieve bend filter or a combination of at least two of these in succession.
In a most preferred embodiment of the installation the mild dewatering separator specifically consists of a rotating drum filter.

The invention furthermore also provides a method for an integrated energy efficient treatment of manure and/or at least one organic waste stream, comprising a bio-fermentation thereof with recovery of generated biogas, electricity production from said biogas with a generation engine also producing heat, separating the slurry obtained from the bio-fermentation into a moist concentrated solid fraction and a solid poor liquid fraction, using a preliminary mechanical separation operation and a subsequent membrane filtration, and drying said moist solid fraction using said heat, in which organic waste treatment method the preliminary mechanical separation specifically comprises at least one mild dewatering operation and the subsequent membrane filtration specifically consists of vibrating membrane filtration.

According to a preferred feature of the organic waste treatment method according to the invention, the membrane filtration suitably consists of vibrating reversed osmosis membrane filtration.

In a specific embodiment of the organic waste treatment method a coagulation and flocculation operation is preferably applied to the slurry obtained from the bio-fermentation before the mild dewatering operation is applied.

According to another preferred feature of the organic waste treatment method according to the invention the mild dewatering operation is suitably selected from a straining-belt / belt-sieve operation, a thickening table operation, a rotating drum filter / rotating drum sieve operation, a sieve bend / barred grate / perforated bend / barred sieve operation, or a combination of at least two of these in succession.
In a preferred embodiment of the invention the mild dewatering operation is specifically a filtration operation by means of a rotating drum filter.

The invention finally also specifically provides an installation for an integrated energy efficient treatment of manure and/or at least one organic waste stream, comprising a bio-fermenting unit with recovery of generated biogas, an electricity generation engine operated at least partially with said recovered biogas, a primary mechanical separator and a subsequent membrane filtration unit for separating a solid fraction from the slurry resulting from the bio-fermenting unit, and a dryer for said solid fraction operated at least partially with heat generated by said generation engine, in which integrated treatment installation the preliminary mechanical separator

specifically comprises at least one mild dewatering separator and the subsequent membrane filtration unit consists of vibrating membrane filtration unit.
In a preferred embodiment feature of the integrated treatment installation the membrane filtration unit specifically consists of a vibrating reversed osmosis membrane filtration unit.

According to another preferred embodiment of the integrated treatment installation the mild dewatering separator is selected from a straining-belt / belt-sieve, a thickening table, a rotating drum filter, a sieve bend filter or a combination of at least two of these in succession.

In a most preferred embodiment of the integrated treatment installation the mild dewatering separator suitably comprises or consists of a rotating drum filter.

The methods / installations according to the invention, as disclosed above, make it possible (depending on the concentrations of the incoming streams) to meet the following requirements for the quality of the resulting "solid poor liquid fraction" (maximum content limit) :

COD (Chemical Oxigen Demand) :	< 125 mg/l
BOD (Biochemical Oxigen Demand):	< 125 mg/l
total amount of suspended matter :	< 25 mg/l
total amount of nitrogen :	< 15 mg/l
total amount of phosphor :	< 2 mg/l

as well as the further requirements according to the official VLAREM standards (in particular those of annex 5.3.2 of the VLAREM II decree and annex 2C of the VLAREM I decree, the content of which decrees and annexes is hereby incorporated by reference in the present text).

The methods / installations according to the invention are capable to provide a solid fraction (thick fraction), after mechanical dewatering, with more than 25% dry matter, preferably more than 30% dry matter, most preferably more than 32,5% dry matter, and/or a solid fraction after mechanical dewatering involving at least 60% dewatering, preferably at least 75 % dewatering, most preferably at least 80 % dewatering.
The methods / installations according to the invention are capable to provide a combined solid fraction to be dried (combining a solid fraction after mechanical dewatering and a concentrate from a membrane filtration) having less than 20 % dry matter, preferably less than 22% dry matter.

The requirements as stated here above and as referred to in the stated decrees constitute preferred features according to the invention.

Detailed description of the invention

According to a preferred embodiment of the invention, the organic dispersion, such as a bio-digestate coming out of the digester, enters the end treatment system.
The process / installation according to this embodiment of the invention most suitably involves, first, an online (static mixer) addition of lime, iron or aluminium salts to coagulate the dispersion and the coagulated mixture is directly sent to a mixed tank.
This mixture is pumped over another static mixer, where flocculent polymer is online injected.

The obtained sludge (with the suspended flocs) enters a reaction tank (with a slow mixer inside the reaction tank). This tank is filled up with the flocculated sludge and at a certain moment the liquid runs in a "thickening drum" (rotating drum filter). Possible alternatives thereto are for instance a belt-sieve device or a thickening table. A rotating drum filter has however shown most appropriate in most circumstances.

A typical rotating drum filter very suitably involves an inner Archimedes screw conveying (mildly) the draining filter slurry through the rotating drum (without applying substantial "squeezing" pressure on the slurry.

The liquid fraction of the bio-digestate after the thickening drum is collected in a tank. The thick fraction coming out of the drum is squeezed in a screw press. The pressed thick fraction is collected.

The liquid fraction of the screw press goes in the same tank as the liquid fraction resulting from the thickening drum. The liquid fractions are blended and the pH is regulated. After pH regulation the liquid fraction is pumped to a buffer tank.

A batch tank (with level control) is filled with feed of the buffer tank. This feed passes a pre-filter unit to remove large particles and is pumped by 2 high pressure transfer pumps to a vibrating membrane filtration using a reversed osmosis membrane. Most suitably a membrane for maximum rejection of multivalent and monovalent ions is used.

The liquid fraction treated in the vibrating membrane filtration is separated into two streams :

a concentrated bio-digestate slurry ("concentrate"), and

a clear filtrate (permeate).

The concentrate flows back into the batch tank; the permeate is transferred to a polishing system, designed to remove excess dissolved ammonia/ammonium nitrogen from the solution; after polishing the permeate goes to a decantation laguna and is drained.

When 80% permeate is recovered the concentration operation is interrupted and the system is flushed with hot permeate water (permeate that has been heated 50-60°C) from a so called CIP (“Cleaning in Place”) tank. After each concentration operation the vibrating membrane filter system is briefly (for a few seconds) flushed whereas the flushing slurry is removed from the filter pack and returned to the buffer tank.

The concentrate is pumped from the batch tank to the concentrate tank and the batch tank is again filled up with feed from the buffer tank. When the batch tank is full, the concentration operation starts again.

After several batches the concentrate tank is emptied and dried in the dryer together with the pressed thick fraction coming out of the screw press.

The operation sequence for the bio-digestate coming out of the digester and entering the "end treatment" system can be specifically described as follows :

1. Digestate conditioning

1a. The process involves first the online (static mixture) addition of lime, iron or aluminium salts to coagulate the digestate.

1b. In a subsequent entry point flocculent polymers are online injected to flocculate the coagulated mixture.

1c. The flocculated sludge enters a reaction tank with a slow-working paddle inside. This tank is filled up with the flocculated sludge until the content is transferred to the separation unit.

2. Separation unit

2a. The flocculated digestate enters a rotating drum filter / drum sieve, (acting as "mild dewatering" separator). This filter contains rinsing sprinklers to avoid clogging of the filter material.

(alternative "mild dewatering" separators : belt filter / straining belt separators, thickening table separators, sieve bend / barred grate / perforated bend / barred sieve separators).

2b. The liquid fraction of the biodigestate after the thickening drum is collected in a tank.

2c. The thick/solid fraction coming out of the drum is transferred to secondary separation unit for additional dewatering.

2d. The secondary dewatering instrument is a fan press (screw press). The thick fraction is collected coming out of this press is collected as the final solid fraction of the separation phase.

2e. The liquid fraction of the screw press is transferred in the same tank as the liquid fraction of the drum filter, mentioned in 2b.

3. Filtration of liquid fraction

3a. The liquid fractions coming from the fan press and the drum filter are blended and the pH is regulated to slight acidic conditions. The pH must be maintained above pH 2 to avoid damage to the membrane systems mentioned in 3b, and must be below pH 6 to convert gaseous NH3 to dissolved NH4+. After pH regulation the liquid fraction is pumped to a buffer tank.

3b. A subsequent batch tank (with level control) is filled with feed of the buffer tank.

3c. This feed passes over a pre-filter unit to remove large particles.

3d. The pre-filtered feed is subsequently pumped by 2 high pressure transfer pumps to a vibrating membrane filtration (such as in particular vibrating membrane filtration units involving the so called "VSEP"-technology). A reversed osmosis membrane is used for maximum rejection of multivalent and monovalent ions.

3e. The liquid fraction, sent to the vibrating membrane filtration is split into two streams: a concentrated biodigestate slurry (concentrate) and a transparent filtrate (permeate) : the concentrate is pumped to the concentrate tank, the permeate is transferred to a polishing system.

4. Permeate "polishing" (i.e. "nitrogen removal")

(possible alternatives : ammonia stripping, "struvite" precipitation, biological reactor, reversed osmosis membrane, etc.)

4a. The permeate enters a reaction vessel where pH is controlled and regulated to slightly acidic conditions (pH 5-7).

4b. The permeate is directed over an ion-exchange resin containing substrate designed to remove NH4-nitrogen from the permeate. By doing so, total nitrogen content in the permeate is reduced to below 15 mg/l.

4c. The exchange resin is periodically regenerated using NaOH, NaCl and water. The resulting regeneration water, containing high concentrations of NH4/NH3 is processed further by re-acidification and recycling to the vibrating reversed osmosis filtration instrument for an additional filtration step (for instance by being returned to the storage tank where also the liquid fractions from the mechanical dewatering operations arrive, thus allowing proper pH regulation).

5. Drier

5a. The thick/solid fraction collected in 2d mixed with the concentrate collected in 3e is dried with the heat coming from the biogas engines.

Description of the drawings.

Figure 1 is an overall schematic flow diagram illustrating the mass balance of the treated materials.

Figure 2 discloses calculated values for the composition / quality of the filtrate after mechanical conditioning (dewatering) and of the permeate after membrane filtration (VSEP) for typical starting materials (fermented and unfermented manure)

While in the foregoing, embodiments of the present invention have been set forth in considerable detail for the purposes of making a complete disclosure of the invention, it may be apparent to those of skill in the art that numerous changes may be made in such details without departing from the spirit and principles of the invention.

CLAIMS

1. Method for separating an aqueous liquid dispersion of organic material into a concentrated solid fraction and a solid poor liquid fraction, comprising an optional coagulation and flocculation operation, a preliminary mechanical separation operation and subsequent membrane filtration, **characterised in that** the preliminary mechanical separation comprises at least one mild dewatering operation and the subsequent membrane filtration consists of vibrating membrane filtration.

2. Method according to claim 1, **characterised in that** said mild dewatering operation leads to a liquid fraction containing less than 2% dry matter.

3. Method according to any one of claim 1 and 2, **characterised in that** said membrane filtration consist of vibrating reversed osmosis membrane filtration.

4. Method according to claim any one of the preceding claims, **characterised in that** a coagulation and flocculation operation is applied to the aqueous liquid dispersion of organic material and **in that** said mild dewatering operation is applied to a slurry as resulting from said coagulation and flocculation operation.

5. Method according to any one of claim 1 to 4, **characterised in that** said mild dewatering operation is selected from a straining-belt / belt-sieve operation, a thickening table operation, a rotating drum filter / rotating drum sieve operation, a sieve bend / barred

grate / perforated bend / barred sieve operation, or a combination of at least two of these in succession.

6. Method according to any one of claim 1 to 4, **characterised in that** said at least one mild dewatering operation comprises a filtration operation by means of a rotating drum filter.

7. Method according to any one of the preceding claims, **characterised in that** said aqueous liquid dispersion of organic material is manure, a fermentation disgestate thereof, a fermentation digestate of an organic dispersion, or a mixture of several of those.

8. Installation for separating an aqueous liquid dispersion of organic material into a concentrated solid fraction and a solid poor liquid fraction, comprising a mechanical primary separator and a subsequent membrane filtration unit, **characterised in that** the preliminary mechanical separator comprises at least one mild dewatering separator and the subsequent membrane filtration unit consists of a vibrating membrane filtration unit.

9. Separation installation according to claim 8, **characterised in that** said membrane filtration unit consists of a vibrating reversed osmosis membrane filtration unit.

10. Separation installation according to any one of claims 8 and 9, **characterised in that** said mild dewatering separator is selected from a straining-belt / belt-sieve, a thickening table, a rotating drum filter, a sieve bend filter or a combination of at least two of these in succession.

11. Separation installation according to any one of claims 8 and 9, **characterised in that** said mild dewatering separator is a rotating drum filter.

12. Method for an integrated energy efficient treatment of manure and/or at least one organic waste stream, comprising a bio-fermentation thereof with recovery of generated biogas, electricity production from said biogas with a generation engine also producing heat, separating the slurry obtained from the bio-fermentation into a moist concentrated solid fraction and a solid poor liquid fraction, using a preliminary mechanical separation operation and a subsequent membrane filtration, and drying said moist solid fraction using said heat, **characterised in that** said preliminary mechanical separation comprises at least one mild dewatering operation and the subsequent membrane filtration consists of vibrating membrane filtration.

13. Organic waste treatment method according to claim 12, **characterised in that** said membrane filtration consist of vibrating reversed osmosis membrane filtration.

14. Organic waste treatment method according to any one of claims 12 and 13, **characterised in that** the solid poor liquid fraction resulting from the vibrating membrane filtration is submitted to a nitrogen removal step.

15. Organic waste treatment method according to any one of claims 12 to 14, **characterised in that** a coagulation and flocculation operation is applied to the slurry obtained from the bio-

fermentation and **in that** said mild dewatering operation is applied to the resulting slurry.

16. Organic waste treatment method according to any one of claims 12 to 15, **characterised in that** said mild dewatering operation is selected from a straining-belt / belt-sieve operation, a thickening table operation, a rotating drum filter / rotating drum sieve operation, a sieve bend / barred grate / perforated bend / barred sieve operation, or a combination of at least two of these in succession.

17. Organic waste treatment method according to any one of claim 12 to 16, **characterised in that** said mild dewatering operation comprises a filtration operation by means of a rotating drum filter.

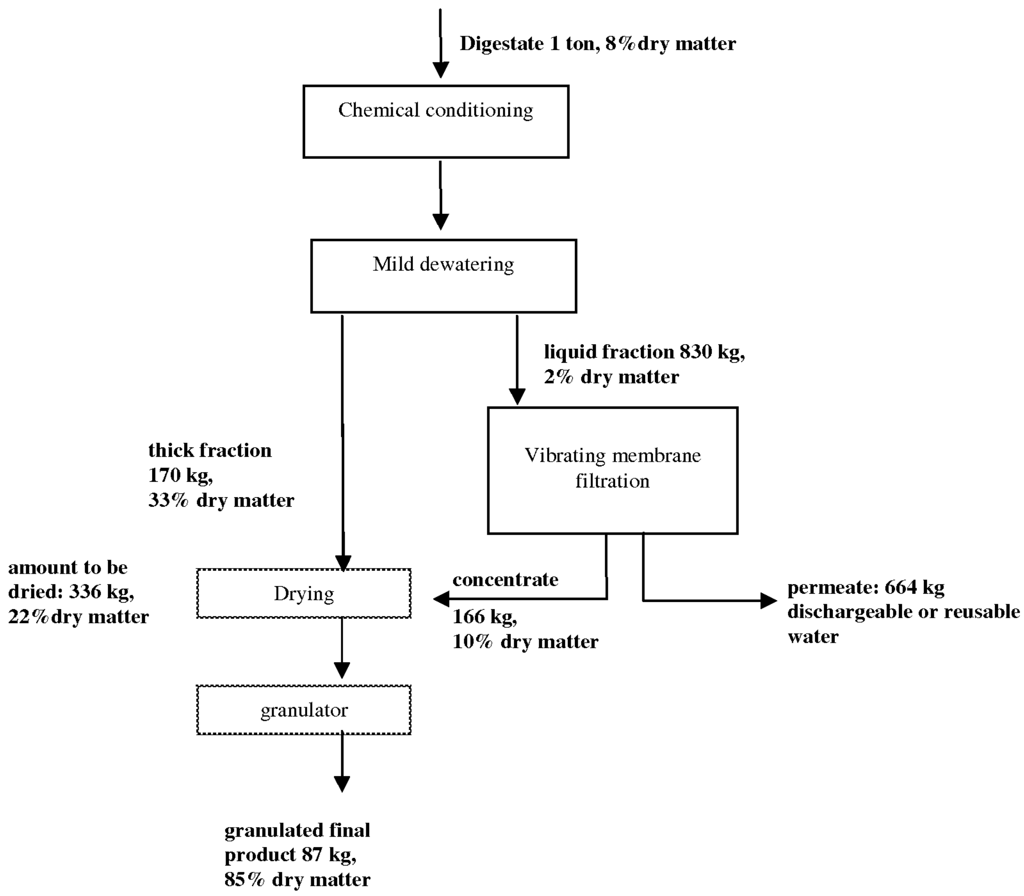
18. Installation for an integrated energy efficient treatment of manure and/or at least one organic waste stream, comprising a bio-fermenting unit with recovery of generated biogas, an electricity generation engine operated at least partially with said recovered biogas, a primary mechanical separator and a subsequent membrane filtration unit for separating the slurry obtained from the bio-fermentation unit into a moist concentrated solid fraction and a solid poor liquid fraction, and a dryer for said solid fraction operated at least partially with heat generated by said generation engine, **characterised in that** said preliminary mechanical separator comprises at least one mild dewatering separator and the subsequent membrane filtration unit consists of vibrating membrane filtration unit.

19. Integrated treatment installation according to claim 18, **characterised in that** said membrane filtration unit consists of a vibrating reversed osmosis membrane filtration unit.

20. Integrated treatment installation according to any one of claims 18 and 19, **characterised in that** said mild dewatering separator is selected from a straining-belt / belt-sieve, a thickening table, a rotating drum filter, a sieve bend filter or a combination of at least two of these in succession.

21. Integrated treatment installation according to any one of claims 18 - 20, **characterised in that** said mild dewatering separator comprises is a rotating drum filter.

Fig. 1


Digestate 1 ton, 8% dry matter
Chemical conditioning
Mild dewatering
liquid fraction 830 kg, 2% dry matter
thick fraction 170 kg, 33% dry matter
Vibrating membrane filtration
amount to be dried: 336 kg, 22% dry matter
Drying
concentrate 166 kg, 10% dry matter
permeate: 664 kg dischargeable or reusable water
granulator
granulated final product 87 kg, 85% dry matter

	Unfermented Manure	% Reduction Conditioning	Filtrate from conditioning	% Reduction VSEP	Permeate from VSEP
dry matter	7,50%	85,7%	**1,07%**	98,6%	**0,02%**
dissolved matter	5,80%	93,7%	**0,37%**		
N	6.010 ppm	55,4%	**2.680 ppm**	96,4%	**96 ppm**
C/N	4	85,9%	**0,564**		
N-NH3	3.500 ppm			94,5%	
N-org	2.500 ppm				
P-P2O5	1.567 ppm	96,5%	**55 ppm**	98,1%	**1,04 ppm**
K-K2O	3.319 ppm	20,4%	**2.642 ppm**	98,9%	**29 ppm**
Mg-MgO	1.025 ppm	96,7%	**34 ppm**	100,0%	**0 ppm**
Na-Na2O	668 ppm			100,0%	
pH	7,3				

	Fermented Manure	% Reduction Conditioning	Filtrate from conditioning	% Reduction VSEP	Permeate from VSEP
dry matter	5,30%	85,7%	**0,76%**	98,6%	**0,01%**
dissolved matter	3,60%	93,7%	**0,23%**		
N	6.200 ppm	55,4%	**2.765 ppm**	96,4%	**100 ppm**
C/N	3	85,9%	**0,423**		
N-NH3	4.100 ppm			94,5%	
N-org	2.100 ppm				
P-P2O5	2.030 ppm	96,5%	**71 ppm**	98,1%	**1,35 ppm**
K-K2O	3.485 ppm	20,4%	**2.774 ppm**	98,9%	**31 ppm**
Mg-MgO	1.447 ppm	96,7%	**48 ppm**	100,0%	**0 ppm**
Na-Na2O	594 ppm			100,0%	
pH	8				

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/058356

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D61/02 A01C3/02 C02F3/28 C02F9/00 C02F11/04
C12M1/107

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B01D A01C C02F C12M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 245 121 B1 (LAMY PIERRE-YVES [FR] ET AL) 12 June 2001 (2001-06-12) column 1, line 56 - line 58; figures 1,2 column 9, line 54 - column 11, line 58	1-13, 15-21
Y	EP 0 426 219 A (BS WATERSYSTEMS B V [NL]) 8 May 1991 (1991-05-08) column 3, line 20 - column 4, line 29; figure 1	1,3-5, 7-10,12, 13,15, 16,18-20
Y	WO 2004/011377 A (UNIV CALIFORNIA [US]; ZHANG RUIHONG [US]; TURNBULL JANE H [US]) 5 February 2004 (2004-02-05) paragraphs [0003], [0004], [0089]; figures 1-3; examples; table 6	1-4,7-9, 12-15, 18,19

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[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 April 2008	02/05/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Goers, Bernd

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