

METHOD FOR UPGRADING WASTE AND CORRESPONDING DEVICE

The present invention relates to the field of substrate
5 treatment, in particular, with a view to upgrading them.

By "substrate(s)", is meant indistinctly any type of waste:
household, green, or industrial waste or biomass. Mostly,
substrates come in partly solid form. They comprise organic
elements and possibly inorganic elements.

10 More particularly, the invention relates to a first of its
purposes, a method for upgrading substrates at least partly
organic and at least partly solid, comprising steps consisting
in:

- 15 A. introducing a plurality of volumes of fresh substrates
into a plurality of respective percolators,
- B. humidifying the volume of substrates of at least one
percolator, in order to ensure a hydrolysis of at least
one portion of the organic constituents of said volume,
- 20 C. injecting the leachate from at least one humidified
volume of substrates into an anaerobic digester for
producing biogas,
- D. sending a portion of the liquid from the digester back
into at least one percolator for step B, and
- E. repeating steps B to D for a determined period.

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Such a method is known by the skilled person.

However, the substrates (particularly household) usually
require upstream of the humidification a complex and costly
mechanical preparation step, thus highly reducing the portion
30 of organic fraction which is sent for digestion and which can in

addition cause significant constraints of exploitation and maintenance, particularly due to the presence of inerts.

Furthermore, the substrates (biomass, green waste, papers and cardboard) contain an important fraction of undegraded organic matter during the anaerobic digestion, their treatment by digestion hence usually leads to an overdimensioning of the digesters.

Furthermore, in the prior art, it is provided a single phase percolation step in which steps A and B are implemented in a closed and sealed enclosure, such as to produce biogas and channel the produced biogas.

The present invention proposes a method substantially characterized in that:

for step C, all the leachate from said humidified volume of substrates is injected directly into the anaerobic digester, and in that beyond a threshold time value, for a volume of substrates of one at least of said percolators, the method further comprises:

F. a step of aerobic fermentation consisting in performing a first phase of composting said volume of substrates in said percolator by aerobic fermentation, by stopping the humidification thereof and by airing said percolator, and

G. a step of aerobic maturation consisting in performing a second phase of composting said volume of substrates by aerobic maturation, by removing said fermented volume of substrates from said percolator and by positioning said volume in an aerobic storage device in order to obtain a stabilized compost, whereof the humidity rate is lower

than a maximum threshold value and/or higher than a minimum threshold value.

5 For example, the humidity rate ranges between a minimum threshold value equal to 25% and a maximum threshold value equal to 70%, a rate higher than 25% allowing to prevent the formation of dust during the spreading. The maximum and/or minimum threshold values of the humidity rate may for example correspond to a standard or
10 regulation in force.

Advantageously, the method further comprises steps consisting in:

15 H. extracting all or a portion of the liquid from the digester, and

I. oxygenating all or a portion of the extracted liquid before sending it into at least one percolator for the step B.

20 Thus allowing in particular to limit the presence of methanogenic bacteria in a percolator.

The extraction of the liquid from the digester may be carried out in one time or in several times.

25 It can be further provided a step consisting in mixing the leachate in the anaerobic digester with other liquid or stodgy organic substrates from other sources with a methanogenic potential.

30 In one embodiment, one at least of the volumes of fresh substrates comprises inorganic elements, the method further comprising a separation step, subsequent to the second composting phase, for separating the organic

elements from the inorganic elements by different known separating techniques.

5 Compared to the traditional technologies of organic substrate treatment containing inorganic elements in which the separation step is performed upstream of the introduction of a plurality of volumes of fresh substrates into a plurality of respective percolators, this allows to limit the handling of the substrates and
10 optimize the costs of treatment.

Advantageously, it may be provided a step consisting in introducing a new volume of fresh substrates into the percolator whereof the volume of substrates has been
15 removed for the aerobic maturation step.

Thus, allowing to obtain a constant production of methane within the digester, by sequentially replacing the volume of substrates of the percolators.

20 It may be provided a step prior to the introduction step and consisting in making the organic matter accessible to the liquid used for the humidification step.

25 In one embodiment, it is further provided a step of detecting methane and/or hydrogen sulphide in a percolator, possibly paired with the step of airing said percolator during the first composting phase.

30 In one embodiment, it is further provided a step of chemically analyzing the leachate and/or the liquid used for the humidification step.

Preferably, the step of aerobic fermentation is linked to the step of chemically analyzing the leachate and/or the liquid used for the humidification step.

5 It may further be provided a step of measuring the temperature of the substrates in a percolator, the step of aerobic maturation being linked to the results of the temperaturemeasuring step at least during the aerobic fermentation step.

10 According to another of its purposes, the invention relates to a device for upgrading substrates at least in part organic and at least in part solid, liable to implement the method according to the invention, the device comprising:

- 15 - a plurality of percolators in which a plurality of volumes of respective fresh substratesmay be introduced,
- 20 - sprayers for humidifying the volume of substrates of at least one percolator, and performing a hydrolysis of one portion at least of the organic constituents of said volume,
- an anaerobic digester for producing biogas,
- 25 - at least one pump for injecting the leachate from at least onehumidified volume of substrates in the digester, and
- at least one pump for sending a portion of the liquid from the digester back into at least one percolator.

30 The device is substantially characterized in that it further comprises:

- at least one piping per percolator whereby all the leachate from said humidified volume of substrates is injected directly into the anaerobic digester,
- a device for stopping the humidification of a percolator,
- at least one ventilator for performing a first phase of composting the volume of substrates of a percolator by aerobic fermentation, and
- at least one aerobic storage location or device, different from a percolator, to perform a second phase of composting said volume of substrates by aerobic maturation in order to obtain a stabilized compost, whereof the humidity rate is lower than a maximum threshold value and/or higher than a minimum threshold value.

It may be further provided at least one piping for extracting a portion of the liquid from the digester, and an airtank for oxygenating said extracted portion.

It may also be further provided a device for separating the organic and inorganic elements of the stabilized compost, whereof the humidity rate is lower than a maximum threshold value and/or higher than a minimum threshold value.

Thanks to the invention, it is possible to reduce the portion of the organic fraction placed in a non-hazardous waste storage facility (NHWSF).

Thanks to the invention, it is possible to treat organic substrates integrally, that is to say in solid form and in liquid form.

The present invention allows to effectively solve the world issue pertaining to the reduction of substrate burial.

The absence of handling of the substrates in a percolator, or even during the aerobic maturation phase allows to simplify the industrial exploitation and reduce the implementation and maintenance. Furthermore, this improves the health of workers
 5 since the method according to the invention generates less dust and bioaerosols caused by the numerous substrate handling operations of the prior art.

Other features and advantages of the present invention will become apparent upon reading the following description given
 10 by way of non limiting illustrating example and made with reference to the accompanying figs. in which:

- fig.1 illustrates an embodiment of the method according to the invention, and
- fig.2 illustrates an embodiment of the device according
 15 to the invention.

Generally, it is provided that the substrates, in this instance household waste, be directly accessible to the liquid making the hydrolysis possible. However, it happens that the substrates be inaccessible, for example because they are
 20 enclosed in plastic bags. In this case, it is provided a step 100 consisting in making the organic matter accessible, usually by opening or even removing the plastic bags, prior to the step of introduction into a percolator. Thus, the organic matter may be humidified by the liquid of the percolator, as
 25 described later. The dots of fig.1 illustrate the optional aspect.

It is proposed here to upgrade the substrates in both solid form (as such) and liquid form (that is to say the liquid extracted from the substrates in solid form).

30 To this end, it is proposed to introduce 110 a plurality of volumes of fresh substrates 10 as is, that is to say, without mechanical shaking or grinding them, in a plurality of

respective percolators 20, for example by mechanical means 11 such as a conveyor, a transporter or even a feeder. As opposed to the techniques of the prior art, leaving the substrates fresh as is allows to increase substrate treatment speed for reasons that will be outlined later. A volume of substrates is an arbitrary unit volume, for example a determined volume, the volume of a bag, the volume of a percolator, etc.

By fresh substrates is meant substrates which have not undergone any prior industrial chemical major upgrade transformation, that is to say for example substrates directly from a collection point.

A percolator 20 is a waterproof but not a gasproof enclosure, it is fitted with sprayers 21 allowing to humidify or water the volume of substrates within it and thus ensure a hydrolysis of a portion at least of the organic constituents of said volume in a humidification or indistinctively a percolation phase.

Between the introduction of the substrates and the aerobic maturation step, the total volume of liquid sprayed onto the volume of substrates during the humidification 120 is preferably higher than the volume of substrates in the percolator 20.

Preferably, once the humidification 120 of the substrates is implemented, new substrates are not reintroduced in a percolator 20 before the second composting phase, called aerobic maturation phase, described later.

In a percolator, the liquid sprayed onto the volume of substrates (also called substrate mass) for the humidification step (also called percolation or watering) 120 flows by gravity and gets loaded with organic matter when in contact with the substrates 10. This percolation step allows an extraction step, by collecting the liquid at the exit in the form of

leachate (also called seepage water) in a piping 22, thanks to pores located at the bottom and/or on the sides of the percolator 20.

As the substrates have been left as is, inside the percolator, with no prior mechanical grinding or shaking or in the percolator, there are aerobic pockets naturally within the substrate mass.

Furthermore, the structure, density and particle size of the mass allow to facilitate the flow of the liquid sprayed within the mass, thus improving the conditions of hydrolysis and limiting risks of biogas production.

Despite the aerobic conditions of the percolator, it may occur that unwanted gases (CH_4 , H_2S) be created. Hence, it may further be provided a step 130 of detecting methane and/or hydrogen disulfide in a percolator, and airing means (non illustrated) for removing these gases if need be, for example a ventilator allowing to ventilate unwanted gases into a specific (not illustrated) piping in order to prevent the unwanted gases from escaping from the percolator 20 into the atmosphere. In fact, the regulatory constraints impose to upgrade or burn biogas.

The leachate from a humidified volume of substrates is injected 140, for example thanks to at least one non illustrated pump, from the piping 22 into an anaerobic digester 30 which is a distinct equipment of the percolators 20, which is liquid and gas proof. The anaerobic digester 30 allows to produce biogas from the leachate in an anaerobic digestion phase. Advantageously, the anaerobic digester comprises other liquid or stodgy organic substrates from other sources and which have a methanogenic potential, for example sludge produced by the factories which treat municipal and industrialeffluents, with which the leachate is mixed, thus

allowing for example to optimize the use of a digester on a site by using a same digester for several percolators and/or several substrate upgrading methods, for example sewage sludge.

- 5 The humidification in the percolators (of which only one is illustrated in fig.1) hence allows to hydrolyze the organic matter contained in the substrates and extract it by liquid process in order to produce biogas within the anaerobic digester 30.
- 10 In a percolator, the humidification step 120 is preferably controlled, for example via a calculator controlling the output of the sprayers 21. It may be provided to discontinuously humidify, for example based on a humidification profile, that is to say a quantity of given
15 liquid, depending for example on the volume of substrates, possibly their thickness, and the time, with reference to a reference model, for example stored in a memory and accessible to the calculator.

- Thanks to the injected liquid, the humidification step 120
- 20 allows to maintain adequate humidity for hydrolyzing the organic matter, that is to say, allows the solubilization and transformation of organic macromolecules into volatile fatty acids (VFA). It also allows to draw along, by solubilization the VFA and other soluble organic molecules, that is to say,
25 transport the dissolved organic matter towards the digester 30.

- All the leachate from the different percolators is sent directly towards the anaerobic digester 30, by at least one piping 22 per percolator. That is to say, that contrary to the
- 30 solutions of the prior art, there is no direct recirculation of leachate in input of a percolator: the leachate is inevitably treated by the digester 30 before a possible

recirculation. This allows to optimize the production of biogas in the digester.

Preferably, it is provided that the liquid from the digester in part sent to at least one percolator is the supernatant of the digester. Thus, it may be provided to extract 150, by at least one piping 31 and at least one pump (not illustrated), all or part of the supernatant from the digester 30. In this case, it is preferably provided to oxygenate 160 said extracted portion, in this instance in an aired tank 40.

Preferably, it is provided that all the liquid from the digester is sent to at least one percolator.

It may hence be provided a step of aerobically treating 160 the supernatant of the anaerobic digester, thus allowing to eliminate the methanogenic bacteria contained therein and reduce or even eliminate the concentration of nitrogen in the form of ammonia dissolved therein, thus optimizing the extraction potential of the liquid in the percolators when it is reinjected thereto and limiting the risks of producing methane in a percolator.

To this end, the tank 40 for treating the supernatant may for example have an airing system that can be adjusted in power and operating mode for example binary (on/off).

The treated supernatant thus becomes all or part of the extractor liquid used in the percolators for the humidification step in a percolation-digestion cycle. According to the water balance of a percolator, it may be provided to complete the treated supernatant by adding "process" water, that is to say, wastewater or other leachates.

A portion at least of the liquid from the digester is hence sent back via a piping 41 and at least one pump (not illustrated) into at least one percolator 20 for the

humidification step. The steps of humidification, digestion and reinjection are repeated cyclically for a determined duration, depending, in particular on the nature of the substrates 10.

- 5 It may be provided a mixed mode wherein only one portion of the supernatant from the digester sent to the percolator undergoes oxygenation; the other portion of the supernatant being mixed with the oxygenated portion for the humidification step.
- 10 It may be further provided a step of chemically analyzing 170 the leachate and/or the liquid used for the humidification step, in this instance comprising the supernatant. The chemical analysis of the leachate and/or that of the supernatant or even the comparison of the chemical analysis of
15 the leachate with that of the supernatant allows to provide an indication on the methanogenic potential of a substrate volume.

- For example, the step of chemically analyzing the leachate, includes a measurement of the Chemical Oxygen Demand (COD), in
20 the piping 22 at the output of the percolator. The COD is a parameter used for example for measuring the organic load of a solid or liquid substrate, expressed as the quantity of oxygen required for oxidizing the organic matter of said solid or liquid substrate.

- 25 Once the humidification step finished, it is provided an aerobic fermentation step 181 in the percolator 20, thus allowing a first phase of composting the volume of substrates.

- Preferably, the aerobic fermentation is implemented according to the result of the chemical analysis step; for example
30 according to the difference between a threshold value and the absolute value of the difference between a reference value and

the value of the result of the chemical analysis step 170 of the leachate.

The aerobic fermentation is implemented by stopping the humidification of the percolator. For example thanks to a
 5 stopping device such as a controlled valve or pump arranged on the piping connecting the output of the digester, in this instance on the piping 41 connecting the outlet of the aired tank with the inlet of the percolator. Aerobic fermentation allows to eliminate the pathogenic germs of the substrates in
 10 the percolator and produce a non-mature compost.

The level of maturity of the compost corresponds to the level of stability of its organic matter, it is hence function at the same time of the type of composted substrate and the applied method. The level of maturity may be expressed by
 15 different indicators, the most common one being the Rottergrad, graded from I to V, a fresh or non-mature compost corresponding to a Rottergrad II to III, described for example in the following URL

http://wiki.laboratoirelca.com/index.php/test_de_maturit%C3%A9
 20 . According to compost uses, different levels of maturity may be sought.

It is indistinctly meant a mature compost.

Furthermore, in order to increase the fermentation speed, it is provided a step of mechanical airing the percolator 20. For
 25 example it is provided at least one ventilator (not illustrated). The ventilation further allows to eliminate possible traces of methane or hydrogen disulfide.

As the substrates have been left as is, without mechanical grinding or shaking, there are aerobic pockets naturally which
 30 facilitate the flow of air within the mass and the aerobic fermentation.

Considering that the aerobic fermentation occurs in the same enclosure as the humidification step, the handling of the solid organic substrates is reduced in this instance to nothing as it is not necessary to stir a volume of substrates during the percolation-digestion-reinjection cycle, nor during the aerobic fermentation, or between these two steps, which particularly allows to save time. Furthermore, the absence of mechanical action improves the quality of the produced compost and allows in this instance to produce a high quality compost.

In fact, the unwanted inert contaminants such as plastics, glass, potentially initially present in the treated substrates are more easily and effectively eliminated by the sorting tools, posterior to the biological treatment as they have not been fragmented. This allows to attain in the final composts very low levels of unwanted inerts, such as required by regulation (for example, for French regulations, theregulatory standardNFU 44 051, about whichcan be found elements on the limit values for inerts and impurities at the following URL

[http://wiki.laboratoirelca.com/index.php/NF U 44-051](http://wiki.laboratoirelca.com/index.php/NF_U_44-051)).

Once the aerobic fermentation step is considered finished, for example when it is considered that the organic matter extractable from the volume of substrates of one at least of thepercolators is exhausted, the percolation-digestion-reinjection cycle is stopped, and then a second phase of composting the volume of substrates starts, ensured by aerobic maturation 182.

The purpose of aerobic maturation or aerobic stabilization 182 is to stabilize the remaining organic matter to allow its later agronomical upgrade in the form of compost.

It may be provided a step for measuring the temperature of the substrate in a percolator. Beyond a threshold temperature value, and/or beyond a threshold time value, it may be

considered the step of aerobic fermentation as finished and implement the aerobic maturation step 182.

For example, the progress in time of the temperature of the substrates in a percolator passes by a maximum value, usually 70°C. Preferably, the aerobic maturation step 182 is implemented once the maximum temperature value has been reached.

For the aerobic maturation 182, the volume of solid substrates 10 does not need to remain in the percolator 20. The fermented substrate volume is then advantageously removed from the percolator 20 and moved (symbolized by the full arrow fig.2) to another aerobic location, in this instance an aerobic storage device such as an open-air windrow on a concrete surface 50, in order to obtain a stabilized compost, whereof the rate of humidity is lower than a maximum threshold value and/or higher than a minimum threshold value. Advantageously, the useful volume of the windrow is higher than that of a percolator, thus a windrow may accumulate volumes of substrates from a plurality of percolators. The use of undisturbed air in a windrow also avoids necessarily having a structure (hence costs) for injecting air or oxygen.

It may be provided a system for collecting potential leachates from the windrow which constitute a portion of the aforementioned "process" water, and their discharge towards a percolator or towards the digester.

The aerobic maturation phase 182 allows to completely stabilize the organic matter for a subsequent upgrade in the form of compost. The volume of substrates hence remains for a determined period in this aerobic location 50. This aerobic maturation phase allows to obtain a stabilized compost, compatible with its agronomic upgrade, in particular, when it

is paired with a separation step 190 allowing to separate the organic elements from the inorganic elements.

Composting 180 the substrates is carried out in two phases: an aerobic fermentation phase 181 and an aerobic maturation phase 182.

The percolator 20 liberated from its volume of substrates 10 may be filled with a new volume of fresh substrates for anew percolation-digestion-reinjection cycle.

Generally, a volume of substrates 10 remains in a percolator 20 for a determined period for a percolation-digestion-reinjection cycle, usually a few days. The volume of substrates 10 then undergoes an aerobic fermentation phase 181 in a percolator for a determined period, usually a few weeks. The volume of substrates is then removed from the percolator 20 and placed in another location 50 in aerobic maturation 182 for a determined period, usually a few months.

In some cases, one at least of the volume of substrates further comprises inorganic elements, which are not upgradable in biogas form or compost form.

It is further provided a separation step 190, subsequent to the second composting phase, for separating the organic elements from the inorganic elements. To this end, separation means (not illustrated) are used for example granulometric separation means, aeraulic means, optical means, density separation means and more.

Advantageously, thanks to a downstream separation, the substrates are neither ground, mixed nor screened upstream of the treatment stream, thus allowing a much easier and less costly disposal of the unwanted inorganic elements, thus particularly allowing to avoid the presence of inerts (for example glass) in the compost. The separation on a downstream

compost drier than the fresh substrates implies a very important reduction of cost of the separation step, particularly as the mass to be treated is significantly reduced and that the viscosity is lesser, hence the performance of the separation equipment increases significantly.

Furthermore, it is worth noting that the separation step 190 implies supplying energy to the mechanical separation means. However, at this stage, the organic substrates have been partially upgraded in liquid form thanks to the digester. The methane production of the latter may hence advantageously allow to supply energy to said mechanical separation means.

The separation step 190 also allows to obtain an inorganic matter of better quality since it is free from organic matter. The inorganic matter may be upgraded for example as Solid Recovered Fuel (SRF), or for different recycling or storage usages.

Thanks to the invention, solid substrates are left to rest: they are not moved as long as they are in a percolator, and may not be moved either during the aerobic maturation step, thus allowing to obtain a high quality compost without inert shards.

Thanks to the invention, the humidification step may last for a maximum of three weeks and the aerobic fermentation step may last for a maximum of six weeks. As a result, a volume of substrates remains in the percolator for a maximum of two months.

This very rapid treatment in less than two months has the following advantages:

- to be able to increase the production of a treatment site,

- to reduce the surface required for storing the fresh substrates, and
- to further allow the production of a high quality compost.

5 Advantageously, the method may be free from any thermal treatment of the leachate, thus particularly allowing to save cost and room.

It is worth noting that the substrates remain solid in the percolator for the humidification just as for the aerobic
10 fermentation, they are not stodgy and cannot be pumped.

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CLAIMS

5 1.A method for upgrading biomass or substrates at least partly organic and at least partly solid, comprising steps consisting in:

10 A. introducing (110) a plurality of volumes of fresh substrates (10) into a plurality of respective percolators (20),

B. humidifying (120) the volume of substrates of at least one percolator (20), in order to ensure a hydrolysis of at least one portion of the organic constituents of said volume,

15 C. injecting (140) the leachate from at least one humidified volume of substrates into an anaerobic digester (30) for producing biogas,

D. sending one portion at least of the liquid from the digester back into at least one percolator for step B, and

20 E. repeating steps B to D for a determined period,

characterized in that

for step C, all the leachate from said humidified volume of substrates is injected directly into the anaerobic digester (30),

25 and in that beyond a threshold time value, for a volume of substrates of one at least of said percolators, the method further comprises steps consisting in:

30 F. a step of aerobic fermentation (181) consisting in performing a first phase of composting said volume of substrates in said percolator by aerobic fermentation

(181), by stopping the humidification thereof and by airing said percolator, and

5 G. a step of aerobic maturation (182) consisting in performing a second phase of composting said volume of substrates by aerobic maturation (182), by removing said fermented volume of substrates from said percolator (20) and by positioning said volume in an aerobic storage device (50) in order to obtain a stabilized compost, whereof the humidity rate is lower than a maximum
10 threshold value and/or higher than a minimum threshold value.

2. The method according to claim 1, further comprising steps consisting in:

15 H. extracting (150) all or a portion of the liquid from the digester, and

I. oxygenating (160) all or a portion of the extracted liquid before sending it into at least one percolator for the step B.

20 3. The method according to any one of the preceding claims, further comprising a step consisting in mixing the leachate in the anaerobic digester with other liquid or stodgy organic substrates from other sources with a methanogenic potential.

25 4. The method according to any one of the preceding claims, in which one at least of the volumes of fresh substrates comprises inorganic elements, the method further comprising a step subsequent to the second composting phase (182), for separating (190) the organic elements from the inorganic elements.

30 5. The method according to any one of the preceding claims, comprising a step consisting in introducing a new volume of fresh substrates into the percolator (20) whereof the volume

of substrates has been removed for the aerobic maturation step (182).

6. The method according to any one of the preceding claims, comprising a step (100) prior to the introduction step and
5 consisting in making the organic matter accessible to the liquid used for the humidification step.

7. The method according to any one of the preceding claims, further comprising a step (130) of detecting methane and/or hydrogen sulphide in a percolator (20), possibly paired with
10 the step of airing said percolator during the first composting phase.

8. The method according to any one of the preceding claims, further comprising a step (170) of chemically analyzing the leachate and/or the liquid used for the humidification step.

15 9. The method according to claim 8, in which the aerobic fermentation step (181) is linked to the analysis step (170).

10. The method according to any one of the preceding claims, further comprising a step of measuring the temperature of the substrates in a percolator (20),

20 the step of aerobic maturation (182) being linked to the results of the temperature measuring step at least during the aerobic fermentation step (181).