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Description

The invention relates to a method for soil stabilization by means of a geomaterial web and to the use of a geomaterial web for soil stabilization.

Geomaterial webs, also known as geotextiles (or classic geosynthetics), are used in a variety of ways to stabilize soil layers. Typical examples of the various uses of geomaterial webs include embankment reinforcement, dyke construction, bank protection on rivers and lakes, stabilization of embankments in landfill areas or stabilization of roadways and track construction. Geomaterial webs are generally installed at a predetermined depth, i.e. they are covered by soil layers, but can also be installed on the surface in individual cases.

The geomaterial web takes on the task of stabilizing the soil layer and layer boundaries between soils, i.e. preventing erosion or soil displacement and mixing, preventing or reducing soil material displacement, for example through flow-induced removal and reaccumulation of soil material, and preventing the overall slipping of soil layers. Geomaterial webs can be used as a permanent solution, especially where natural processes such as root penetration or other soil consolidation mechanisms cannot stabilize the soil layer or the layer boundaries. In many applications, geomaterial webs are installed to achieve a temporary, temporary mechanical stabilization effect that stabilizes the soil layer to such an extent that plant growth is achieved and additional stabilization of the soil layer can be achieved in the long term by rooting through these growing plants. A geomaterial web used as a reinforcement mat is known from EP 2 439 342 A1.

One problem associated with such geomaterial webs is that the artificial material introduced into the ground poses a potential environmental risk, whereby this environmental risk occurs at the installation site itself or, if the geomaterial web is broken up into smaller sections and moves away from the installation site due to mechanical influences or other impacts, at other locations. In order to overcome these disadvantages, it has generally been proposed to produce geomaterial webs from biodegradable materials. DE 295 16 797 U1, for example, discloses a covering layer made of a material, whereby the material can consist of natural fibers. US 2013/0344759 A1 discloses a geotextile with a non-woven structure in which plant fibers are used for production. For this purpose, hemp fibers are proposed as a substitute for previously known jute or coconut fibers.

From EP3385426A1 a fiber structure material is known, which is designed for an increased water absorption capacity. The fiber structure of this previously known material is designed as a three-dimensional fiber framework of interconnected thick and thin fiber sections, which is produced from a lyocell solution. This fiber structure material has the disadvantage that it has a uniform biodegradability due to the three-dimensional direct connection of the fiber sections to each other and therefore does not comprise two structure materials with different biodegradability.

A textile sealing membrane made of lyocell fibers is already known from US2009/0317583A1. This sealing membrane does not have two structural materials with different biodegradability.

5 However, the disadvantages of the biodegradable geotextiles proposed in this way are that the desired mechanical soil stabilization is not guaranteed over the required period of time in many applications, the mechanical protective effect is lost due to the biodegradation and undesirable soil movements such as landslides, dike damage and the like can occur. Although a fiber coating is proposed to avoid these problems, this runs counter to the actual goal of achieving biodegradability and creates an environmental risk from the coating. The use of biodegradable geotextiles made from the above-mentioned natural fibers can therefore not provide satisfactory results in many applications or fails with regard to the time requirements for the mechanical fastening effect. DIN EN 12225 therefore specifies test criteria for geosynthetics in order to demonstrate general resistance to microbial degradation.

15 It is therefore the task of the invention to propose a method for stabilizing soil layers with a geomaterial web and uses of geomaterial webs for stabilizing soil layers, which ensure reliable mechanical stabilization over the necessary period of use, but at the same time reduce the environmental impact.

20 According to the invention, this task is solved by a method for location-dependent soil stabilization by means of a geomaterial web, comprising the following steps:

Determining the intensity of an influencing parameter at the installation site, whereby the intensity of the influencing parameter is selected from:

- Intensity of a radiation effect of an electromagnetic radiation,
- Height of a temperature,
- 25 - Concentration of a substance that reacts chemically and/or biochemically with the geomaterial web,
- concentration of a concentration of bacteria, and/or
- Concentration of fungi,

Determination of one or more of these influencing parameters at a transfer site at a distance from the installation location,

- Installation of the geomaterial web at the installation site, wherein the geomaterial web comprises a structural material which
 - 5 ○ shows biodegradability under the intensity of the influencing parameter at the place of shipment to the extent that a residual portion of the shipment remains in a sieve of 2 mm within six months if the material or its components are sieved,
 - 10 ○ whereby the residual proportion of the material is less than 30% by weight,
 - exhibits biodegradability under the intensity of the influencing parameter at the site of incorporation to the extent that within six months a residual amount of the material remains in a sieve of 2 mm when the material or its components are sieved,
 - 15 ○ where the installation site residual portion is greater than the transfer site residual portion.

According to this aspect of the invention, site-dependent soil stabilization is achieved by means of a geomaterial web. This is to be understood as meaning that the geomaterial web has a biodegradation period at the installation site and a biodegradability at the transport site which differs therefrom and which, as before, can be defined, for example, analogously to the standardization of a degradability according to ISO16929 or the marine degradation test - but with the parameters determined at the installation site or at the transport site. According to the conditions prevailing at the installation site, more than 10% by weight, in particular more than 25% by weight or more than 80% by weight of the structural material may remain as particles in a sieve of 2 mm after a period of six months or twelve weeks. This results in a reduced biodegradation rate at the installation site, which is sufficient for numerous soil stabilization applications and ensures reliable degradation of the geomaterial web. This biodegradability is achieved under the conditions at the installation site, in particular the aforementioned influencing parameters of temperature, radiation, oxygen, bacteria and/or fungi concentration or the like. In contrast, the material in the process according to the invention has a higher biodegradability at a place of transportation.

Under the conditions there, fewer particles of the material remain in a 2 mm sieve after six months or twelve weeks than under the conditions at the installation site. Preferably less than 80% by weight, in particular less than 25% by weight or less than 10% by weight of the structural material can be achieved within the six months or twelve weeks in the conditions prevailing there with a higher degradation rate.

The transfer site can be a place where the geomaterial web is transferred after removal at the installation site, for example to a landfill, and which differs from the installation site in terms of one of the influencing parameters. For example, a planned higher oxygen concentration and/or a stronger UV radiation and/or bacteria and/or fungi concentration may prevail at the landfill site and cause the accelerated biodegradation of the geomaterial web. The place of transfer can also be a place to which the geomaterial web arrives completely or in fragments if it is exposed by environmental influences or other influences, is mechanically attacked and then, for example, is exposed, floats or is contaminated by other effects. In this context, a place of movement can also be understood to mean that an original installation of the geomaterial web at the installation location below a soil layer changes in such a way that the soil layer is removed and the geomaterial web is exposed as a result. This is the case, for example, in many marine applications in coastal protection and scour protection, where water and wave movements can cause the material to be separated and moved from the installation site to a transfer site. At the transfer site, the geomaterial web is degraded at an accelerated rate and therefore does not represent a relevant environmental impact.

It is preferable if the installation site has an environment that has a lower temperature and/or a lower oxygen content and/or a lower concentration of bacteria and/or fungi compared to the place of installation. These influencing parameters are particularly suitable for viscose-based geomaterial webs such as lyocell in order to achieve the different biodegradation rate at the installation site compared to the place of installation.

In particular, the installation site may be located on the seabed and the geomaterial web may float to the surface due to currents and/or density differences or reach the surface due to anthropogenic influences. The installation site is therefore characterized by a higher oxygen concentration and temperature in the upper water layers and increased UV radiation, which accelerates degradation.

It is even more preferred if the structural material is a viscose-based material, in particular Lyocell. Such a structural material has proven to be particularly suitable for the selectively

accelerated biodegradation rates at the place of application compared to the place of installation.

According to this aspect of the invention, the geomaterial web is thus used such that it comprises a structural material which

- 5 - exhibits biodegradability under a first intensity of an influencing parameter at an installation site to the extent that
- In a composting test with the following parameters
 - Samples with a length of 10cm, a width of 10cm and an original material thickness
 - 10 ○ 50°C +/- 5°C
 - thermophilic conditions according to ISO 16929, unless these are defined by specific intensities of specific influencing parameters at the installation site,
 - Sieving out the solids after six months in a sieve with a mesh size of 2 mm (mesh 8.75)
 - 15 more than 50 % by dry weight of the starting material remains in the sieve during sieving, or that
 - in a marine incubation test, with the following parameters:
 - Samples with a length of 2cm, a width of 2cm and an original material thickness
 - 20 ○ 30°C +/- 2°C
 - Aerobic conditions in seawater with a salt content of 3.5 wt.% +/- 1 wt.%, unless these are defined by specific intensities of specific influencing parameters at the installation site,

- Sieving out the solids after 4, 8 and 12 weeks in a sieve with a mesh size of 2 mm (mesh 8.75)

5 more than 10 % by dry weight, in particular more than 25 % by dry weight or more than 80 % by dry weight of the starting material remains in the sieve after 12 weeks of sieving, and

shows biodegradability under a second intensity of the influencing parameter at a place of shipment to the extent that within six months in the composting test or twelve weeks in the marine incubation test

10 less than 80 % by weight, in particular less than 25 % by weight or less than 10 % by weight of the dry mass of the first structural material remains in the sieve after sieving through a 2 mm sieve, the intensity of the influencing parameter being selected from:

- an intensity of a radiation effect of an electromagnetic radiation
- a height of a temperature,
- a concentration of a substance that reacts chemically and/or biochemically with the geomaterial web,
- 15 - a concentration of bacteria,
- a concentration of fungi,

in such a way that the geomaterial web is installed at the installation site at one time and transported to the transport site at a later time following the installation time.

20 According to this use, a geomaterial web is used in such a way that it has a predetermined degradation rate at an installation site that does not exceed a certain biological degradation rate, which is achieved by the above-mentioned influencing parameters prevailing there. In contrast, the geomaterial web is used in such a way that when it is transported from the installation site to a transfer site, which can take place by scheduled transportation or un-

25 scheduled transportation, it has a higher degradation rate and thus biodegrades more quickly at the transfer site compared to the installation site. This accelerated degradation

is achieved by the dependence of the degradation rate on a different intensity of an influencing parameter there - if necessary also by several different influencing parameters, which prevail in different intensities at the place of installation and at the place of shipment - and which are used as influencing parameters instead of the specified parameters in the previously defined material tests for composability or marine degradation. Biodegradability according to the invention is defined according to the principle of the ISO 16929 standard or according to a marine degradation test developed by TÜV Austria Belgium. The material according to the invention must fulfill at least one of these two conditions, preferably both.

- According to ISO16929, the compostability of a material is proven if it fulfills three criteria.
- One of these criteria is defined in such a way that after 84 days in a controlled composting process, no more than 10% by weight of the material remains in a sieve of 2 mm when the material or its components are sieved. Based on this system and adapted to the needs of geomaterials, the first structural material has a first biodegradability in which no more than 50% by weight of the dry matter of the first structural material remains in the sieve after sieving through a 2mm sieve within six months in controlled composting according to ISO 16929 under thermophilic composting conditions. The first material therefore does not necessarily qualify as compostable within the meaning of ISO16929. However, it may be compostable or it may achieve degradation of the 90% by weight particles <2mm over a period longer than six months.
- The degradation test under marine conditions simulates the degradation of standardized samples under an accelerated simulation in seawater. Here too, the degree of degradation is determined by a final sieving based on the dry weight remaining in the sieve. However, the more intensive mobility of the material is simulated by two intermediate sieving tests after 4 and 8 weeks.
- Both degradation tests are carried out using test specimens with defined dimensions. The length and width are defined, while the thickness is based on the original material, i.e. the thickness of the material in the produced construction method. In the case of layered composites in which the first and second structural materials are arranged in separate, superimposed layers and bonded together, this can be the thickness of the material in the respective layer. If the original material is produced as a composite layer, for example as a fleece or as a layer woven, knitted or otherwise bonded from two different fibers, a sample of the material in the original material thickness of the layer, which is made only from the material to be tested, is to be used for the purposes of the degradation test.

According to a further aspect of the invention, the task set at the beginning is solved by a geomaterial web comprising a first viscose-based fibrous material, in particular lyocell.

According to this aspect of the invention, the geomaterial web comprises a viscose-based fibrous material. This viscose-based fibrous material can be used as a first structural material or second structural material in the geomaterial web. In principle, regenerated cellulose fibers such as lyocell are well suited as a material or component of geomaterial webs according to the invention.

The geomaterial web can consist solely of the first viscose-based fibrous material or can contain further structural materials, in particular further fibrous materials. A viscose-based fibrous material can in particular be a material made of viscose fibers, i.e. generally a material consisting of man-made fibers made of regenerated cellulose. Typically, the cellulose is processed as a filament yarn or as a spun fiber, for example in a wet spinning process. According to the inventors, viscose fibers have proven to be particularly suitable for providing the targeted biodegradation required for geomaterial webs. On the one hand, the viscose fiber can be adapted to a desired rate of biodegradation under predetermined environmental conditions at the installation site by modifying the fiber length, the crimp and by using different finenesses, i.e. fiber thicknesses. Viscose fibres can also be metabolized by numerous living organisms and can therefore be classified as environmentally harmless.

A viscose-based fibrous material, such as Lyocell, may in particular also be used as the first and/or second structural material according to the first aspect of the invention.

In particular, the inventor has recognized viscose fibres of the genus Lyocell as suitable. These fibers are a type of viscose fiber which is produced by a solvent spinning process in which the cellulose is dissolved directly in an organic solvent without forming a derivative and the solution is spun. This manufacturing process, especially when using the organic solvent NMNO (N-methylmorpholine-N-oxide), is environmentally friendly both in production and in terms of the manufactured product. According to the invention, wood pulp can preferably be used as the cellulose starting material. According to the knowledge of the inventors, Lyocell has proven to be biodegradable in typical environmental conditions in soil layers and has a degradation rate which can interact with rooting rates in new plantings in such a way that when a sufficient degree of rooting is achieved for the mechanical stabilization of an embankment, the degree of biodegradation of the geomaterial web is also so far advanced that rooting is neither significantly hindered nor are there any significant residual amounts of the geomaterial web in the further course of time. According to the

inventors, Lyocell is also well suited for differentiated biodegradation. Lyocell biodegrades faster under increased oxygen, bacteria and/or fungi concentrations in the environment and increased UV radiation than under low oxygen, bacteria and/or fungi concentrations and low UV radiation. This allows a geomaterial web to be installed as planned for soil layer stabilization and to provide the mechanical properties required for soil stabilization at this installation site over the desired period of time, but to degrade more quickly if it is intentionally or unintentionally moved to another location where other conditions, such as increased oxygen, bacterial and/or fungal concentration or UV radiation, are present. This selectivity of the degradation rate is advantageous, for example, for use on the seabed with low concentrations of oxygen, bacteria and fungi and low temperatures and low UV radiation, as lyocell that floats up unintentionally or is moved to locations with different environmental conditions is then degraded more quickly. This can also be advantageous for coastal protection and shoreline stabilization measures, where lyocell, if exposed, is then degraded at an accelerated rate due to the increased UV radiation and increased concentration of bacteria and/or fungi.

According to a preferred embodiment, the first fibrous material is designed as a non-woven fabric or knitted or woven fabric and is processed into a textile fabric in the geomaterial web by mechanical bonding, knitting or weaving. This type of bonding of the first fibrous material results in a resilient geomaterial web that is well suited to the mechanical loads for soil layer stabilization. At the same time, the processing method achieves a favorable degradation behavior with the provision of perforations or enlargement of openings as well as a degradation of the mechanical properties. The first fibrous material can be combined with one or more identical fibrous materials to form a nonwoven fabric, knitted fabric or woven fabric. Furthermore, the first fibrous material can be formed with a second fibrous material as a nonwoven fabric or knitted fabric or woven fabric, which is different from the first fibrous material in terms of the material or the modification of the fibers. In particular, this allows a first structural material and a second structural material to be combined to form a geomaterial web.

According to a further preferred embodiment, it is provided that the first fibrous material is processed with a second fibrous material, which is different from the first fibrous material, to form a textile fabric. Such a textile fabric is formed from two different fibrous materials or more than two different fibrous materials. The textile fabric can be designed as a nonwoven, knitted or woven fabric or a combination thereof.

Still further, it is preferred that the first pulp differs from the second pulp in having a different fiber thickness, a different chemical nature, a different surface roughness, a different degree of draw, a different opening or mesh size, or a different tensile strength-elongation behavior, or a different breaking strength, or a combination of two or more of these properties. According to this embodiment, the first and second fibrous materials differ in one or more of seven properties which influence both the mechanical properties and the biodegradation rate of the fibrous material. This formation of the textile fabric ensures that the biodegradation rate and the mechanical behavior over the service life of the first fibrous material is different from that of the second fibrous material, which can be achieved both due to a different material composition (chemical composition) and due to a modification of materially corresponding fibrous materials.

According to the invention, the geomaterial web described above is used to be incorporated into a soil layer for the purpose of soil stabilization. As explained above, this soil stabilization can be used for embankment reinforcement, bank reinforcement, dike reinforcement in coastal protection, the reinforcement of the seabed against scour effects, the reinforcement of the soil layer along traffic routes. These applications are characterized by the fact that, on the one hand, biodegradation of the geomaterial web at the installation site itself is advantageous and desirable in order to dissolve the geomaterial web after a certain degree of root penetration or other solidification of the soil layer has been achieved. On the other hand, properties of the geomaterial web are desired in these applications which mean that when the geomaterial web is transported from the installation site to another location, for example due to mechanical decomposition, is carried by the wind, floats or is carried by other currents, it decomposes more quickly at this other location compared to the installation site and/or can be metabolized by flora and fauna compared to conventional products.

A further aspect of the invention relates to the use of a geomaterial web comprising a structural material which

- exhibits biodegradability under a predetermined intensity of an influencing parameter at an installation site to the extent that
- in a composting test with the following parameters:

- o Samples with a length of 10cm, a width of 10cm and an original material thickness

- 50°C +/- 5°C
- thermophilic conditions according to ISO 16929, unless these are defined by specific intensities of specific influencing parameters at the installation site,
- 5 ○ Sieving out the solids after six months in a sieve with a mesh size of 2 mm (mesh 8.75)

less than 50 % by dry weight of the starting material remains in the sieve during sieving, or

- in a marine incubation test, with the following parameters:

- 10 ○ Samples with a length of 2cm, a width of 2cm and an original material thickness
- 30°C +/- 2°C
- Aerobic conditions in seawater with a salt content of 3.5 wt.% +/- 1 wt.%, unless these are defined by specific intensities of specific influencing parameters at the installation site,
- 15 ○ Sieving out the solids after 4, 8 and 12 weeks in a sieve with a mesh size of 2 mm (mesh 8.75)

less than 20 % by dry weight of the starting material remains in the sieve after 12 weeks.

- 20 where the predetermined intensity of the influencing parameter is selected from:

- an intensity of a radiation effect of an electromagnetic radiation
- a height of a temperature,
- a concentration of a substance that reacts chemically and/or biochemically with the geomaterial web,

- a concentration of bacteria,
- a concentration of fungi,

for stabilizing a soil layer in flood protection or scour protection.

According to this aspect of the invention, a geomaterial web, in particular a geomaterial web of the type described above, is used to achieve soil stabilization for scour protection or flood protection. Any type of bank reinforcement on the seashore, on the banks of flowing and standing waters and lakes can be provided as flood protection, whereby the geomaterial web can be arranged in the area below the water surface or above the water surface with optional drying or wetting. In this case, it serves to stabilize the bed, embankment or dyke and can be used permanently or temporarily during the construction work until a sufficient degree of rooting with vegetation is achieved. In this context, scour protection is understood to mean protection against the displacement of soil material by currents. Here too, permanent or temporary protection of the soil can be provided by the geomaterial web. In particular, such scour protection can be provided, for example, by flexible containers filled with particulate material such as sand or the like, which are made from the geomaterial web and placed on the soil layer to be stabilized.

The geomaterial web is used in such a way that targeted biodegradation is achieved. On the one hand, this targeted biodegradation can consist in the fact that, unlike in the previously known applications, biodegradability occurs at the installation site itself and the geomaterial web consequently disintegrates as planned within a certain period of time. The biodegradability can also be provided in such a way that the geomaterial web has a higher biodegradability at a transfer site than at the installation site. This ensures that if the geomaterial web is intentionally or unintentionally transported away from the installation site, it biodegrades more quickly at a transport site with other influencing parameters and therefore does not represent an environmental burden.

It is preferable that the geomaterial web is used to produce fillable containers and that these containers are used in such a way that they are placed on the seabed when filled, thereby providing scour protection at locations most exposed to currents. With this training, particularly effective scour protection is achieved.

The use can be further developed by installing the geomaterial web in shore or coastal protection at an installation site with occasional drying or at an installation site with occasional wetting, whereby the geomaterial web preferably has a lower density than water. In particular in the case of occasional drying or wetting, an unintentional release of a geomaterial web can occur during such fixing measures and then the special property of biodegradation can have an advantageous effect.

Another aspect of the invention is a method for soil stabilization using a geomaterial web, comprising the steps of: a) determining a soil parameter value characterizing a soil property at an installation site, b) determining a degradation value characterizing a biodegradation rate, c) selecting a mixing ratio of a first and second structural material, which have different biodegradability, on the basis of the soil parameter value and the degradation value, d) combining the first and second structural material to form a geomaterial web in the mixing ratio, e) providing the geomaterial web for installation at the installation site.

According to this aspect of the invention, a soil reinforcement is carried out at an installation site by providing a geomaterial web there in order to install it in the soil layer at the installation site. For this purpose, soil properties must be known. This means that at least one property of the soil that influences biodegradability in a relevant way is determined or measured. For example, the moisture content of the soil, the pH value, the nutrient concentration, the presence of bacteria and fungi and/or the temperature of the soil can be assumed or determined as the average temperature over a daily period, a weekly period, a monthly period or an annual period. The intensity of UV radiation at the installation site can also be measured.

These installation site-specific parameters take into account the parameters influencing the biodegradation process that prevail at the installation site. A characteristic value can be determined from these parameters, for example as a dimensionless factor or as an empirical value from tables. For example, the compostability or degradation under marine conditions as defined above according to ISO 16929 can serve as a standard reference value and the degradation value can be defined in relation to this reference value, for example by characterizing a lower percentage degradation property due to the soil properties by a corresponding percentage below 100% or by characterizing a higher biological degradation rate at the installation site by the degradation value by using a value above 100% as the degradation value.

Furthermore, a degradation value is determined which defines the time period within which a certain degree of biodegradation of the geomaterial web or a component of the geomaterial web should be achieved.

5 A mixing ratio of a first to a second structural material is then selected based on the soil parameter value and the degradation value. The first and second structural materials have different biodegradability or degradation rates at the soil parameter value. The mixing ratio can be used to provide an overall achieved biodegradation rate of the geomaterial web, which is built up from the first and the second structural material. This biodegradation rate depends on the soil parameter value that was assumed or measured at the installation site
10 and should be selected in such a way that the desired degradation value, which describes the rate of biodegradation of the geomaterial web, is achieved.

After selecting the mixing ratio, the first and second structural materials are combined to form the geomaterial web. This bonding can take the form of a nonwoven, knitted fabric, warp-knitted fabric or in another form and is intended to bond the first and second fibrous
15 materials together in a mechanically resilient manner. The geomaterial web produced in this way is therefore tailor-made for use and targeted biodegradation at the installation site with the conditions prevailing there.

This solution ensures that neither too fast nor too slow biodegradation of the geomaterial web occurs by incorporating the soil parameters that influence biodegradation into the design of the geomaterial web. A specific degradation behaviour, characterized by the degradation value, is set by a mixing ratio of two fibrous materials.
20

The method can be further developed in that the soil parameter value is a soil moisture content of the soil at the installation site, for example between 3 and 300% by weight, a soil pH value of the soil at the installation site, for example between 1 and 13, an enzyme
25 concentration in the soil at the installation site, a temperature between 4°C and 50°C, or a soil parameter value formed from several of these soil parameter values. These soil parameter values are used to determine significant influencing variables on the biodegradation rate of typical fibrous materials, such as viscose fibers like Lyocell, and can therefore be used to form the geomaterial web with a biodegradability individually designed for the
30 installation site.

It is particularly preferred if the degradation value is a strength quotient, formed from the ratio of a mechanical strength value to an installation time of the geomaterial web in comparison to the initial value, a permeability quotient, formed from the ratio of a porosity to an installation time of the geomaterial web in comparison to the initial value, or a degradation characteristic value formed from several of these degradation values. According to this embodiment, the degradation value is defined either as a strength quotient or as a permeability quotient or as a degradation parameter calculated from the strength quotient and the permeability quotient. The strength quotient characterizes the decrease in the mechanical strength of the geomaterial web over the time the geomaterial web remains in the ground. This strength quotient is formed from the ratio of the mechanical strength value at the time of installation, i.e. when biodegradation has not yet occurred, and the mechanical strength value after a predetermined retention time, which can, for example, be standardized to three or six months and characterizes the mechanical strength to a certain degree after biodegradation has occurred. In a similar way, the permeability quotient is determined by setting a porosity at the beginning, i.e. at the time of installation, in relation to a porosity after biodegradation has taken place over a predetermined period of time. By characterizing the degradation values in this way, the desired properties can be specifically determined and consequently influenced by selecting the appropriate material. A strength quotient is in the order of 1.0 to 0 and is typically 0.25, i.e. the strength at a defined point in time is reduced by a factor of four compared to the initial value after biodegradation has taken place. A typical permeability quotient is in the order of one to four powers of ten and is ideally > 10 , i.e. the permeability at a defined point in time after biodegradation has taken place has increased tenfold compared to the initial value.

The specific uses described above and the methods of using them can be further developed by providing the geomaterial web with a polymer group comprising a molecule provided with an isotopic label, in particular a ^{13}C or ^{18}O isotopic label. According to this form of formation, the geomaterial web is provided with an isotopic label and can therefore also be uniquely identified in a later, possibly fragmented form. In this way, any environmental pollution that occurs can be unequivocally assigned or excluded and the cause of such environmental pollution can be quickly and reliably identified.

Furthermore, the method and the use can be further developed in that the geomaterial web comprises a structural material or consists of one or more structural materials which is/are metabolizable. Such metabolization by living organisms, such as mammals, fish or microorganisms such as microbes, leads to reintegration of the geomaterial web into the biological cycle and thus to environmentally harmless disposal. Metabolization can preferably

take place on fragments such as shredded fibre residues of the geomaterial web. In this context, metabolization means, on the one hand, a biologically harmless compatibility of the geomaterial web for living organisms and, on the other hand, the ability of the geomaterial web to be chemically altered and degraded by the metabolic processes in the digestive tract of a living organism.

Furthermore, it is preferred if the geomaterial web is formed by a single-layer or multi-layer filter nonwoven made of at least two different structural materials that are bonded together to form a nonwoven, wherein

- A first structural material exhibits biodegradability under a predetermined intensity of an influencing parameter at an installation site to the extent that
 - In a composting test with the following parameters:
 - Samples with a length of 10cm, a width of 10cm and an original material thickness
 - 50°C +/- 5°C
 - thermophilic conditions according to ISO 16929, unless these are defined by specific intensities of specific influencing parameters at the installation site,
 - Sieving out the solids after six months in a sieve with a mesh size of 2 mm (mesh 8.75)
 - less than 80 % by weight, in particular less than 25 % by weight or less than 10 % by weight of the dry mass of the first structural material remains in the sieve after twelve weeks, or
 - in a marine incubation test, with the following parameters:
 - Samples with a length of 2cm, a width of 2cm and an original material thickness

- 30°C +/- 2°C
- Aerobic conditions in seawater with a salt content of 3.5 wt.% +/- 1 wt.%, unless these are defined by specific intensities of specific influencing parameters at the installation site,
- 5 ○ Sieving out the solids after 4, 8 and 12 weeks in a sieve with a mesh size of 2 mm (mesh 8.75)

less than 80 % by weight, in particular less than 25 % by weight or less than 10 % by weight of the dry mass of the first structural material remains in the sieve when sieving after 12 weeks.

10 where the predetermined intensity of the influencing parameter is selected from:

- an intensity of a radiation effect of an electromagnetic radiation
- a height of a temperature,
- a concentration of a substance that reacts chemically and/or biochemically with the geomaterial web,
- 15 - a concentration of bacteria,
- A concentration of fungi,

and a second structural material is combined with the first structural material to form the filter nonwoven, the second structural material having a lower biodegradability under the same predetermined intensity of the influencing parameter at the same installation site to the extent that within six months under the same conditions a greater percentage by weight of the dry mass of the second structural material remains in the sieve after six months or twelve weeks when sieved through a 2 mm sieve than in the case of the first structural material. According to this form of formation, the geomaterial web is designed as a nonwoven consisting of two different structural materials that have different biodegradation rates under the given, predetermined parameters. This allows the nonwoven material to undergo a targeted mechanical structural weakening through the biodegradation process on the one hand and a geometric change with pore formation, perforation formation or the like on the other, for example to promote a rooting process.

Compared to the first structural material, the second structural material has a second biodegradability which is different, in particular lower, than that of the first structural material, i.e. after six months or twelve weeks, a second percentage by weight of the second structural material remains in the 2mm sieve which is different, in particular higher, than that of the first structural material. For example, if 70% by weight of the first structural material is broken down into particles <2mm in the composting test within six months, a percentage by weight of 60% of the second structural material may be broken down into particles <2mm in the same period under the same conditions.

The invention thus provides a geomaterial web which undergoes a material conversion into carbon dioxide in a defined manner as a result of biodegradation, wherein one of the two structural materials which are included in the geomaterial web or from which the geomaterial web is constructed is biodegraded more quickly than the other. As a result, both geometric and mechanical properties of the geomaterial web can be specifically influenced by the biodegradation. For example, the faster degradation of the first structural material in the geomaterial web can result in the formation of openings or pores that are advantageous for a rooting process, in that the increased space required by the plant roots with increasing rooting is provided by the biodegradation of the first structural material, but at the same time the mechanical stabilization still required is maintained by the second structural material. Furthermore, in the case of woven or knitted fabrics or nonwovens or composites made of the first and second structural material, for example, a mechanical property in a first direction, in which the first structural material essentially runs in the geomaterial web, can be reduced more than a mechanical property in a second direction deviating from this, in which the second structural material essentially runs in the geomaterial web. In the case of slope reinforcement, for example, stability transverse to the direction of the slope can be reduced more quickly than stability in the direction of the slope, whereby the geomaterial web can be made to move easily, which is desirable for plant growth, while at the same time preventing it from slipping in the direction of the slope. The two structural materials can differ, for example, in that the first structural material is made of a different material than the second structural material or contains a different material than the second structural material. The difference can also be that the material of the first and second structural material is identical, but the material of the first structural material has undergone a different material treatment than the material of the second structural material. The first and second structural materials preferably do not differ in terms of specific properties such as fiber thickness and/or fiber length.

In principle, in addition to influencing the geometric and mechanical properties by specifically arranging the first and second structural material in the geomaterial web, the mechanical properties can also be influenced overall over the degradation period of the geomaterial web by selecting and proportioning the first and second structural material. This advantageously enables the biodegradation rate and reduction of the mechanical/geometric properties to be adapted to local conditions at the installation site of the geomaterial web. While the standardized biodegradability is determined under standardized conditions, different influencing parameters for biodegradability can prevail at the installation site. For example, an increased oxygen content can lead to faster biodegradation and, conversely, a reduced oxygen content can lead to slower biodegradation. Furthermore, influencing factors such as increased UV radiation, a high or low pH value, an increased supply of nutrients, an increased proportion of bacteria, an increased proportion of fungi and other factors can influence the rate of biodegradation. Due to the possibility of changing the mixing ratio of the first and second structural material in the geomaterial web according to the invention, the proportion of the second structural material can be increased or vice versa, for example, if an increased biological degradation rate is to be expected due to local influencing factors at the installation site, if influencing factors that reduce the biological degradation rate are to be expected at the installation site, this can be countered by increasing the proportion of the first structural material in order to obtain a geomaterial pathway adapted to the local conditions with a customized biological degradation rate.

Preferably, it is provided that the first biodegradability is greater than the second biodegradability. According to this embodiment, the second structural material has a lower biodegradability than the first structural material, i.e. the second structural material degrades more slowly than the first structural material. In principle, for example, the first structural material can have a degradability in which at least 90% by weight of the first structural material has degraded to particles smaller than 2 mm after six months or twelve weeks, whereas in the second structural material it is only 80% by weight or less. This means that less than 10% by weight of the first material remains in the 2mm sieve, whereas more than 20% by weight remains in the second material. Preferably, the second structural material has a biodegradability in which less than 50% has degraded to particles smaller than 2 mm after six months.

It is even more preferred if the first structural material is arranged in the geomaterial web in such a way that, after partial or complete biodegradation of the first structural material, openings are formed in the geomaterial web that pass through the geomaterial web. According to this embodiment, the faster degradation of the first structural material changes

the geometric appearance of the geomaterial web by creating openings passing through the geomaterial web. Consequently, the first structural material is arranged in the geomaterial web in such a way that it closes these openings in the initial state and exposes these openings or creates these openings as a result of its degradation. The geomaterial web is thus perforated or perforated to a greater extent and consequently adapts to a rooting process which, on the one hand, requires more permeability of the geomaterial web with increasing rooting and, on the other hand, also requires a lower mechanical strength of the geomaterial web. The desired effect of forming openings by breaking down the first structural material can be achieved, for example, by processing the first and second structural materials together to form a nonwoven fabric.

It is further preferred that the first structural material partially or completely penetrates the second structural material. By means of such penetration, on the one hand, a specific, directed or undirected mechanical destabilization of the geomaterial web can be achieved by the biodegradation of the first structural material. On the other hand, certain directed or undirected channels and openings can be created in the second structural material by the biological degradation of the first structural material, which run along the penetration.

It is even more preferred that the first structural material and the second structural material are joined together as a layered composite, the second structural material has a plurality of second perforation openings and the first structural material has no perforation openings, or has a plurality of first perforation openings which are smaller than the second perforation openings. This embodiment ensures that the faster degradation of the first structural material can result in larger openings passing through the geomaterial web as a whole.

A further embodiment provides for the use to be further developed in such a way that the geomaterial web is installed as an element in structures which serve to influence air currents in such a way that, in particular, the speed of the air flow is reduced locally for the purpose of depositing particles which are transported suspended in the air, bounce or roll when the air speed is not reduced. The geomaterial conveyor, the use and the method thus serve to deposit minerals, in particular sand, on coastal sections, for example, which are endangered by sand erosion. The reduction in air velocity thus leads to the deposition of sand, preferably downwind of the structures. The construction is partially or completely sanded in. The geomaterial web according to the invention thus becomes part of the sand deposit, and can be dismantled in accordance with the invention if the structure is located within the sand deposit or, if the structure is exposed again due to a change in the erosion

conditions, it can be dismantled in accordance with the invention at the installation or transfer site.

Preferred embodiments are explained with reference to the figures. They show:

- Fig. 1 a schematic representation of a use of the geomaterial web in accordance
5 with the invention in three different arrangements for coastal protection,
- Fig. 2a, b a use of the geomaterial web according to the invention for embankment reinforcement at two different rooting times ,
- Fig. 3 a schematic representation of a first embodiment of the geomaterial web,
- Fig. 4 a schematic representation of a second embodiment of the geomaterial conveyor,
10 conveyor,
- Fig. 5 a schematic representation of a third embodiment of the geomaterial conveyor,
- Fig. 6 a schematic representation of a fourth embodiment of the geomaterial conveyor.

15 The geomaterial web used according to the invention can basically be installed in three different installation situations with regard to water contact in the embankment area. Starting from a natural shore area 2, which is adjacent to the waterline or, in the case of tidal waters, the average water level and which may be protected against flood situations by an artificial dike 3, a geomaterial web can initially be used in an installation position A in order
20 to stabilize the underwater terrain of the natural seabed course, in which stabilization of the soil with plants is only insufficiently possible. In this installation position A, the geomaterial track is usually under water and can, in exceptional cases, fall dry at low tide or in heavy swell.

In a second installation position B, the geomaterial web is installed on the water side to
25 reinforce the natural embankment and/or the artificial embankment. In this installation position, the geomaterial web stabilizes the generally dry bank portion of the natural embankment and, if applicable, the artificial embankment of the dike. It is therefore usually dry, but can also be under water in flood situations or with strong waves.

In a third installation position C, the geomaterial web is installed in an area, such as the
30 back of the embankment, in which it is not exposed to the water itself and can only be

exposed to stress in special situations such as overflow. In this installation position, the geomaterial web is therefore always dry and, as in any installation position, is only exposed to moisture from rainfall.

Each of the three installation positions requires geomaterial webs to behave differently in order to achieve ecologically favorable behavior. In installation position A, for example, the geomaterial web is required to be stable in an aqueous environment, but if parts of this geomaterial web become detached due to abrasive events and are therefore no longer in the position required to fulfill their function, it is desirable for these detached parts of the geomaterial web to be broken down. According to the invention, this can be achieved, for example, by forming the geomaterial web from a material that is rapidly degraded under the influence of UV radiation. This ensures that parts of the geomaterial web that float up or are washed ashore and torn off are subjected to rapid degradation, whereas mechanical stability is maintained at the installation site when the geomaterial web is not exposed to UV radiation. Instead of specifying the geomaterial web in terms of UV radiation, the biodegradability can also be specified as a function of the oxygen content of the water and/or the bacterial concentration and/or the fungal concentration in certain applications. This is particularly suitable when geomaterial webs are used at great depths in the sea, where low concentrations of the aforementioned influencing parameters prevail. In this case, the material of the geomaterial web can be designed in such a way that it is mechanically stable in the planned installation situation and the surrounding water and biodegrades as soon as the concentration of influencing parameters in the surrounding water or at the installation site is increased.

The installation situation according to C is relevant for the invention, for example, with regard to rooting and the adaptation of the geomaterial web to rooting processes. Figs. 2a and b show two successive rooting situations in which a geomaterial web 10 is installed to stabilize a soil layer 20 at a certain depth in the soil. As can be seen from Fig. 2a, at an early stage, shortly after the soil-stabilizing plants have been planted, the geomaterial web 10 has a high density with only small openings and thus provides a high degree of mechanical stabilization of the soil. The planted plants can penetrate the geomembrane with small root shoots and are therefore not hindered in their growth. An effective mechanical bond between the geomembrane and the plants is already achieved at this early stage.

Fig. 2b shows the same installation situation after a few weeks of plant growth. The geomaterial web has partially decomposed mechanically due to biodegradation. It has larger openings and less mechanical stability. Due to the larger openings, the growing plants are not hindered in their rooting and the enlargement of the root diameters and can therefore

take over the mechanical stabilization function. The geomaterial web according to the invention therefore achieves a continuous shift of the mechanical stability of the soil layer from the geomaterial web to the plants, while at the same time maintaining a good mechanical connection between the plants and the geomaterial web and the geomaterial web continues to have mechanical properties, possibly differing in direction, and assumes functions for stabilizing the soil.

Figs. 3 to 6 show exemplary embodiments of a geomaterial web. In principle, the geomaterial webs according to the invention can be provided in different widths and lengths. Typical widths are greater than 1 m, 1.5 m or 2 m and less than 4 m, 5 m or 6 m and typical lengths are longer than 2 m, 5 m, 10 m, 50 m, whereby the geomaterial web is preferably transportable in a rolled-up state and is unrolled during installation. The thickness of the geomaterial web can be greater than 1 mm, with thicknesses of more than 5 mm, 10 mm or more than 20 mm being preferred. The geomaterial web can have a basis weight greater than 150, greater than 300 or greater than 500 g/m². The basis weight can be less than 1500, less than 2000 g/m² or less than 2500 g/m².

Fig. 3 shows a first embodiment with a top layer 110, a backing layer 120 and a middle layer 130 arranged between the top layer 110 and the backing layer 120. The top and backing layers 110 and 120 can be made of different or matching materials and the middle layer 130 can be designed to match the top layer and backing layer or be made of a different material.

The top layer and the backing layer are connected to one another by means of needling or stitching or interlocking; for this purpose, a plurality of needles 140a, b, c are inserted into the geomaterial web, which connect the top layer to the backing layer through the intermediate layer 130. In this embodiment of a geomaterial web, for example, the top layer can consist of a material which is biodegraded more quickly than the carrier layer 120. As a result, after partial or complete biodegradation of the needling or stitching or interlocking portions of the geomaterial web, channels are formed which extend from the top to the underside of the geomaterial web and provide space for root penetration or drainage effects, for example.

Fig. 4 shows a second embodiment of a geomaterial web which has an upper grid layer 210 and an underlying non-woven layer 220. The grid layer 210 is formed by a crosswise grid of strong individual fibers or rods which form grid openings of a specific size, for example 10 x 10 mm to 40 x 40 mm. The non-woven layer is formed from dense, randomly oriented fibers of a different material to the layer 210. This non-woven layer has the overall

effect of closing the openings of the grid layer 210, resulting in a geomaterial web that is impermeable to coarser particles and permeable to liquids and gases. The non-woven layer 220 is made of a material such as Lyocell and biodegrades faster than the grid layer 210. This reduces the mechanical strength of the geomaterial web within the short biodegradation time of the non-woven layer 220 and the geomaterial web is reduced to the remaining grid layer 210 with the openings formed therein after the non-woven layer 220 has degraded, which in turn provide appropriate space for favorable root penetration.

Fig. 5 shows a third embodiment, which is basically designed as a single-layer geomaterial web. In the geomaterial web, fibers 310 of a first material are arranged in a first direction and fibers 320 are arranged in a second direction transverse to the first direction, thereby forming fiber layers in each case. The fibers 310 and 320 can be connected to each other, for example by welding, bonding, interlacing, needling, weaving techniques or knitting techniques and/or by means of a cover and carrier layer above and below the fibers 310 and 320. The fibers 310 are made of a different material than the fibers 320, whereby the material from which the fibers 320 are formed is biodegraded more quickly than the material from which the fibers 310 are formed. Due to this biodegradation behavior of the geomaterial web, the geomaterial web initially has a load-bearing capacity in the longitudinal and transverse directions, corresponding to the course of the fibers 310, 320. As the biodegradation of the fibers 320 increases, the strength and load-bearing capacity in the longitudinal direction along the course of the fibers 320 decreases, resulting in an anisotropic mechanical load behavior of the geomaterial web.

Fig. 6 shows a fourth embodiment in which two different materials are processed to form a nonwoven layer, which represents a geomaterial web or can represent a layer of a geomaterial web. The two different materials 410, 420 are processed unoriented as short or long fibers or continuous fibers to form a nonwoven and bonded together. The material 420 biodegrades faster than the material 410, whereby the density of the geomaterial web decreases with increasing biodegradation in the installation situation and the geomaterial web becomes more permeable and/or changes its mechanical properties.

In principle, it is to be understood that the four embodiments can also be combined with each other by producing multilayer geomaterial webs therefrom that have combined properties of these embodiments. Furthermore, it is to be understood that the combination of the four embodiments can also be made in such a way that their properties are combined in a single layer of a geomaterial web, for example by forming the lattice structure 210 of the second embodiment with the anisotropically biodegrading fibers 310, 320 of the third embodiment.

The biodegradation behavior can generally be adjusted at the installation site and adapted to the conditions prevailing there. Thus, in all embodiments, the proportion of one material in relation to the proportion of the other material can be increased or decreased in adaptation to the biodegradation properties in order to obtain a desired biodegradation behavior in adaptation to the prevailing conditions. Furthermore, the biodegradation properties can be influenced or even triggered by external influences such as UV radiation and/or oxygen content and/or concentration of bacteria, fungi or chemical influences of the environment, resulting in a specific behavior of the geomaterial webs with regard to biodegradation when they are moved from one location to another location where these specific environmental conditions change.

P A T E N T K R A V

1. Fremgangsmåde til stedafhængig jordstabilisering ved hjælp af en geomaterialebane, der omfatter følgende trin:

udlægning af produktet i henhold til de indflydelsesparametre på indbygningsstedet, hvor indflydelsesparametrene er valgt blandt:

- intensiteten af effekten af elektromagnetisk stråling.
- niveau af en temperatur
- koncentration af et stof, der reagere kemisk og/eller biokemisk med geomateriaelbanen,

- koncentration af en koncentration af bakterier,
- koncentration af svampe,

bestemmelse af en eller flere af disse indflydelsesparametre på et afleveringssted, som er forskelligt fra indbygningsstedet,

- indbygning af geomateriaelbanen på indbygningsstedet, hvor geomateriaelbanen omfatter et strukturmateriale, som:

○ under påvirkning af intensiteten af indflydelsesparameteren på afleveringsstedet udviser biologisk nedbrydelighed i en sådan grad, at der inden for seks måneder forbliver en restandel fra afleveringsstedet i en si med en maskestørrelse på 2 mm, når materialet henholdsvis dets bestanddele sigtes,

○ hvor restandelen fra afleveringsstedet er mindre end 80 vægtprocent, fortrinsvis mindre end 25 vægtprocent eller mindre end 10 vægtprocent af materialet,

○ under påvirkning af intensiteten af indflydelsesparameteren på indbygningsstedet udviser biologisk nedbrydelighed i en sådan grad, at der inden for seks måneder forbliver en restandel fra indbygningsstedet i en si med en maskestørrelse på 2 mm, når materialet henholdsvis dets bestanddele sigtes,

○ hvor restandelen fra indbygningsstedet er større end restandelen fra afleveringsstedet,

hvor installationsstedet fortrinsvis har et miljø, der har en lavere temperatur,

strålingseksponering, ilt, bakterie- og/eller svampekoncentration end overførselsstedet.

2. Fremgangsmåde ifølge krav 1, kendetegnet ved at indbygningsstedet er beliggende på havbunden, og at geomaterialbanen flyder op i havvand som følge af strømning og/eller tæthedforskelle eller bringes dertil.

5

3. Fremgangsmåde ifølge et af kravene 1-2, kendetegnet ved, at strukturmaterialet er et materiale baseret på viskose, især Lyocell.

4. Fremgangsmåde ifølge et af de foregående krav 1-3, kendetegnet ved, at

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- geomaterialbanen omfatter en polymergruppe, der indeholder et isotopmærket molekyle, især en ^{13}C - eller ^{18}O -isotopmærkning, og/eller

- geomaterialbanen omfatter et strukturmateriale eller består af et eller flere strukturmateriale, som er metaboliserbart.

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5. Fremgangsmåde ifølge et af de foregående krav 1-4, kendetegnet ved, at geomaterialbanen dannes af et enkelt- eller flerlagret filtervæv, som er fremstillet af mindst to forskellige strukturelle materialer, som er bundet sammen til et ikke-vævet-væv, hvor

- et første strukturmateriale under en forudbestemt intensitet af en indflydelsesparameter på et installationssted udviser en biologisk nedbrydelighed i en sådan grad, at mere end 50 vægtprocent, især mere end 75 vægtprocent, af strukturmaterialet er omdannet til kuldioxid i et vandigt medium inden for seks måneder,

20

hvor den forudbestemte intensitet af indflydelsesparameteren er valgt blandt:

- intensiteten af elektromagnetisk stråling,

- temperaturen højde,

25

- koncentrationen af et kemisk og/eller biokemisk stof, der reagerer med geomaterialbanen,

- koncentrationen af bakterier,

- koncentrationen af svampe,

- og et andet strukturelt materiale er bundet til det første strukturelle materiale for

30

at danne det ikke-vævede filterstof, hvor det andet strukturelle materiale udviser biologisk nedbrydelighed under den samme forudbestemte intensitet af ind-

flydelsesparameteren på det samme installationssted i det omfang, at

- i en komposteringstest med følgende parametre:

- prøver med en længde på 10 cm, en bredde på 10 cm og den oprindelige materialetykkelse,

5 ◦ 50 °C ± 5 °C,

- termofile betingelser i henhold til ISO 16929,

- sigtning af faststoffer efter seks måneder med en sigte med 2 mm maskestørrelse (mesh 8,75),

10 - er det resterende tørstof i sigten mindre end 50 vægtprocent af udgangsmaterialet, eller

- i en marin inkubationstest med følgende parametre:

- prøver med en længde på 2 cm, en bredde på 2 cm og den oprindelige materialetykkelse,

15 ◦ 30 °C ± 2 °C,

- aerobe betingelser i havvand med en salinitet på 3,5 vægtprocent ± 1 vægtprocent,

- sigtning af faststoffer efter 4, 8 og 12 uger med en sigte med 2 mm maskestørrelse (mesh 8,75),

20 er det resterende tørstof i sigten efter 12 uger mindre end 20 vægtprocent af udgangsmaterialet.

6. Fremgangsmåde ifølge et af de foregående krav 1-5, kendetegnet ved, at geomaterialbanen installeres som et element i strukturer, der tjener til at påvirke luftstrømme på en sådan måde, at især luftstrømmens hastighed reduceres lokalt med det formål at aflejre partikler, der transporteres suspenderet i luften, hopper eller ruller, når lufthastigheden ikke reduceres.

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7. Anvendelse af en geomaterialebane, der omfatter et strukturelt materiale, som

30 - udviser biologisk nedbrydelighed under en første intensitet af en indflydelsesparameter på et installationssted i det omfang at,

- i en komposteringstest med følgende parametre:

- prøver med en længde på 10 cm, en bredde på 10 cm og en oprindelig materialetykkelse,
- 50 °C +/- 5 °C,
- termofile forhold i henhold til ISO 16929, med mindre disse er defineret af specifikke intensiteter af specifikke indflydelsesparametre på installationsstedet,
- sigtning af de faste stoffer efter seks måneder i en sigte med en maskestørrelse på 2 mm (mesh 8,75)
- mere end 80 % af tørvægten, 25 % af tørvægten, 10 % af tørvægten af det oprindelige materiale forbliver i sigten under sigtningen, eller at
 - i en marin inkubationstest med følgende parametre:
 - prøver med en længde på 2 cm, en bredde på 2 cm og en oprindelig materialetykkelse,
 - 30 °C +/- 2 °C,
 - aerobe forhold i havvand med et saltindhold på 3,5 vægt-% +/- 1 vægt-%. % +/- 1 vægt-%, medmindre disse er defineret af specifikke intensiteter af specifikke indflydelsesparametre på installationsstedet,
 - sigtning af faststofferne efter 4, 8 og 12 uger i en sigte med en maskestørrelse på 2 mm (maskevidde 8,75)
 - mere end 80 % af tørvægten, mere end 25 % af tørvægten, 10 % af tørvægten af udgangsmaterialet forbliver i sigten under sigtning efter 12 uger, og
 - under en anden intensitet af indflydelsesparameteren på et overførselssted har en biologisk nedbrydelighed i det omfang, at der inden for seks måneder i komposteringstesten eller tolv uger i den marine inkubationstest er mindre end 80 vægtprocent, især mindre end 25 vægtprocent eller mindre end 10 vægtprocent af tørmassen af det første strukturelle materiale tilbage i sigten efter sigtning gennem en sigte med en maskestørrelse på 2 mm,
- hvor intensiteten af indflydelsesparameteren er valgt blandt:
 - Intensitet af en strålingseffekt af en elektromagnetisk stråling,
 - niveauet af en temperatur,
 - koncentration af et stof, der reagerer kemisk og/eller biokemisk med geomate-

rialebanen,

- koncentration af en koncentration af bakterier,
- koncentration af svampe,
- Forventede mekaniske belastninger.

5 på en sådan måde, at geomaterialebanen installeres på installationsstedet på et installationstidspunkt og transporteres til transportstedet på et senere tidspunkt efter installationstidspunktet.

8. Anvendelse af en geomaterialebane ifølge krav 7 til anvendelse i et jordlag
10 med henblik på jordstabilisering.

9. Anvendelse ifølge et hvilket som helst af foregående krav 7-8, kendetegnet ved, at

- geomaterialebanen omfatter en polymergruppe, der omfatter et isotopisk
15 mærket molekyle, især en ¹³C-eller ¹⁸O-isotopisk mærkning, og/eller
- geomaterialebanen omfatter et strukturelts materiale eller består af et eller flere strukturelle materialer, som kan metaboliseres.

10. Anvendelse ifølge et hvilket som helst af foregående krav 7-9, kendetegnet
20 ved, at geomaterialebanen er dannet af et enkeltlags eller flerlags filtervæv, som er fremstillet af mindst to forskellige strukturelle materialer, som er bundet sammen til et nonwoven-væv, hvor

- et første strukturelt materiale udviser biologisk nedbrydelighed under en forudbestemt intensitet af en indflydelsesparameter på et installationssted i det omfang, at
25 en vægtprocent på mere end 50 %, især mere end 75 %, af det strukturelle materiale omdannes til kuldioxid i det vandige medium inden for seks måneder,

hvor den forudbestemte intensitet af indflydelsesparameter er valgt blandt:

- Intensitet af eksponering for elektromagnetisk stråling,
- niveauet af en temperatur,
- 30 - koncentration af et stof, der reagerer kemisk og/eller biokemisk med geomaterialebanen,

- koncentration af en koncentration af bakterier,
- koncentration af svampe,
- og et andet strukturelt materiale er bundet til det første strukturelle materiale for at danne det ikke-vævede filterstof, hvor det andet strukturelle materiale udviser biologisk nedbrydelighed under den samme forudbestemte intensitet af indflydelsesparameteren på det samme installationssted i det omfang, at
- 5 - I en komposterings test med følgende parametre:
 - prøver med en længde på 10 cm, en bredde på 10 cm og en oprindelig materiale tykkelse,
 - 10 ◦ 50 °C +/- 5 °C,
 - termofile forhold i henhold til ISO 16929,
 - sigtning af de faste stoffer efter seks måneder i en sigte med 2 mm askebredde (maskevidde 8,75)
 - mindre end 50 % af tørvægten af udgangsmaterialet forbliver i sigten under
 - 15 sigtningen, eller
 - i en marin inkubationstest med følgende parametre:
 - Prøver med en længde på 2 cm, en bredde på 2 cm og en oprindelig materiale tykkelse
 - 30 °C +/- 2 °C
 - 20 ◦ Aerobe forhold i havvand med et saltindhold på 3,5 vægt-% +/- 1 vægt-%. % +/- 1 vægt-%
 - Sigtning af tørstofferne efter 4, 8 og 12 uger i en sigte med en maskestørrelse på 2 mm (maskevidde 8,75)
 - mindre end 20 tørre vægt-% af det oprindelige materiale er tilbage i sigten efter
 - 25 12 uger.

11. Anvendelse ifølge et hvilket som helst af foregående krav 7-10, kendetegnet ved, at geomaterialebanen er installeret som et element i strukturer, der tjener til at påvirke luftstrømme på sådan en måde, at især luftstrømmens hastighed reduceres lokalt
- 30 med det formål at aflejre partikler, der transporteres suspenderet i luften, hopper eller ruller, når lufthastigheden ikke er reduceret.

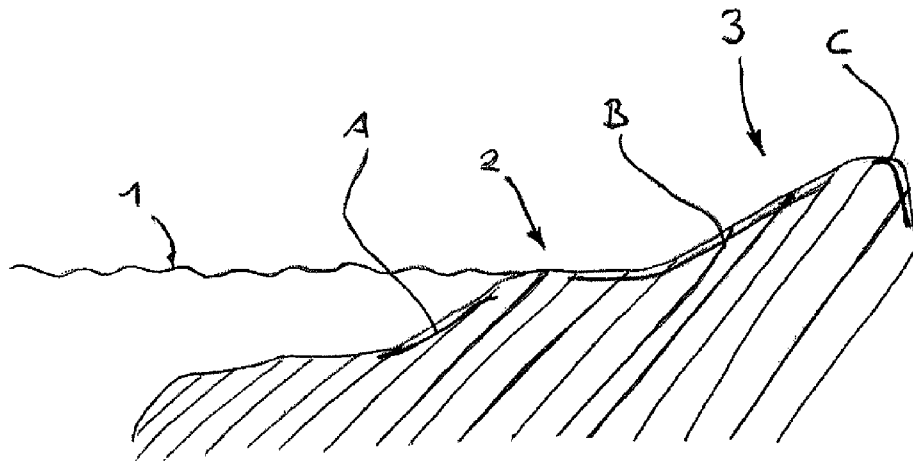


Fig. 1

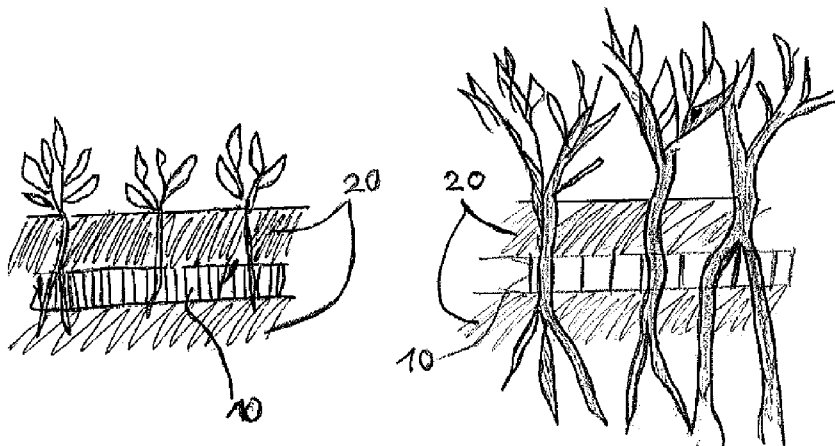


Fig. 2a

Fig. 2b

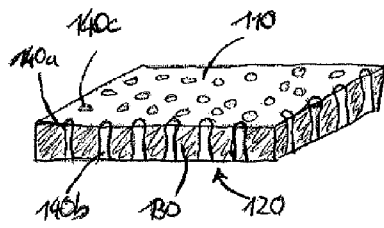


Fig. 3

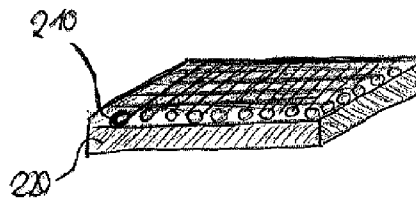


Fig. 4

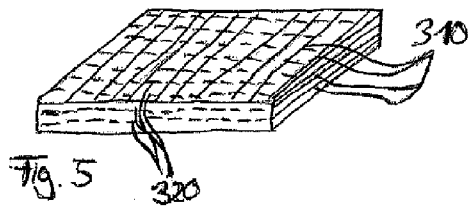


Fig. 5

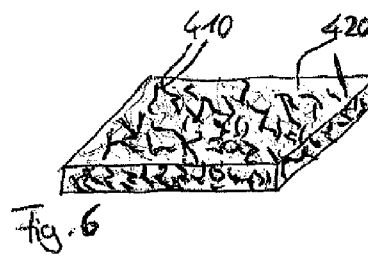


Fig. 6