

Biodegradable drain board

The present invention relates to the core of a drain board made from a composition comprising a polyester, a copolyester, and an inorganic filler. The invention also relates to a process for manufacturing the core of a drain board, to a drain board
5 comprising the core and to the use of the drain board for soil improvement.

Drain boards are used to expedite the consolidation of slow draining soils. They may be used in vertical orientation (vertical drain) or in horizontal orientation (horizontal drain). When used as vertical drains, drain boards are often referred to as
10 “prefabricated vertical drains (PVD)” or “wick drains”. The drain board is normally composed of a core encased by a sheet-like water-permeable material. The core is often made of oil-based plastic. The sheet-like water-permeable material is often referred to as “filter material” or “geotextile”. The core usually contains several, often many, grooves extending in the longitudinal direction of the core along the entire
15 length of the core. In this way, the core provides longitudinal flow paths to allow to drain the soil. The grooves are often called channels.

In order to expedite the consolidation of the soil by using drain boards, the drain boards are very often used as vertical drains. The drain boards are then buried
20 vertically in the soil to be consolidated. In order to further accelerate the process, a preload, for example sand, may be applied on top of the soil, which exerts a stress, thereby increasing the water pressure in the soil. Due to the increase in water pressure in the soil, the water enters the drain board via the geotextile and rises in the channels provided in the cores mainly by the action of the water pressure and
25 capillary forces. With the water being drained from the soil via the channels of the core, the soil is consolidated.

Since the water is transported via the channels during draining, it is important, that the shape of the cores is very regular with regularly shaped cores. If the channels in the core are not well-established and/or irregular, the discharge capacity of the drain board may be diminished.

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Consolidation of compressible soil is normally a slow process that depends on the thickness of the soil layers. The thicker the layers are, the longer it takes. For very thick layers, this process can take up to 30 years. The use of drain boards, for example as vertical drains, normally reduces this time. The reduction largely depends on the grid spacing of the drain and may in average reduce the period to 6 months to a year, but longer period may also occur. This is one of the reasons, why the geotextile and in particular also the cores of drain boards are typically made from durable polyolefins such as polyethylene. However, since it is very difficult to take the drains out of the soil after consolidation of the soil was achieved, they are normally left buried in the soil. However, this pollutes the environment.

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There have been attempts to overcome the environmental issues using biodegradable drains.

For example, JP 2002 266340 A describes a biodegradable drain board that is made from a biodegradable resin. The core of the drain board is made by extruding a molten sheet of the composition from which the core is made by pressing with rollers.

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Generally, the cores of drain boards are normally formed by extrusion because this has been found to be the most economic way of production. With extrusion, it is also easier to implement a continuous manufacturing process.

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A particularly useful type of extrusion for the cores of drain boards is profile extrusion. Profile extrusion is convenient, because it does not require a lot of machinery. For example, when a sheet is extruded first and subsequently formed using rollers, the rollers and additional machinery required may malfunction and need

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service representing a source of downtime. On the other hand, extrusion of a flat sheet followed by shaping of the sheet with rollers allows to obtain items with a regular and accurate structure even when using a material that cannot be shaped into regularly shaped items by other means, such as by profile extrusion.

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The ease of production using profile extrusion is another reason why the cores of the drain boards are typically made from polyolefins because polyolefins can be easily and reproducibly formed into regular shapes by profile extrusion. Polyolefins often show in particular a high reproduction fidelity in profile extrusion and do not require special tools or an adaptation of the process. Thus, with polyolefins, it is possible to prepare regular cores of drain boards with a high accuracy.

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Therefore, it is an object of the present invention to provide a biodegradable drain board. In particular, it is an object of the invention to provide a biodegradable drain board comprising a core that can be made by extrusion, more particularly by profile extrusion. Preferably, the drain boards should have a sufficient service lifetime.

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Other and further objects, features and advantages of the present invention will become apparent more fully from the following description.

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SUMMARY OF THE INVENTION

The invention provides for a core of a drain board manufactured from a composition comprising

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- a. a polyester comprising one or more hydroxycarboxylic acids as monomers,
- b. a copolyester comprising at least one diol component and at least one diacid component,
- c. an inorganic filler,

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wherein the composition comprises at least 5 wt.% of the inorganic filler, based on the total weight of the composition.

The invention further provides for a process for manufacturing the core of a drain board according to the invention, comprising the steps of

- a. providing a composition comprising
 - 5 i. a polyester comprising one or more hydroxycarboxylic acids as monomers,
 - ii. a copolyester comprising at least one diol component and at least one diacid component,
 - iii. an inorganic filler,
 - 10 wherein the composition comprises at least 5 wt.% of the inorganic filler, based on the total weight of the composition,
- b. mixing the composition using thermal and/or mechanical energy,
- c. shaping of the core.

- 15 The invention also provides for a drain board comprising a core according to the invention surrounded by a filter material.

The invention also provides for the use of a drain board according to the invention for soil improvement, in particular as a horizontal or a vertical drain, as earthquake drain,
20 or as a gas drain.

Surprisingly, it was found that the core of a drain board can be manufactured from a composition comprising a polyester comprising one or more hydroxycarboxylic acids as monomers, a copolyester obtained by condensation of at least one diol component
25 and at least one diacid component, and an inorganic filler, wherein the composition comprises at least 5 wt.% of the inorganic filler, based on the total weight of the composition, with good reproduction fidelity by extrusion, in particular even when using profile extrusion. Further, it was found that the resulting drains are biodegradable. Moreover, the resulting drains have a sufficiently long service lifetime.

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Preferred embodiments are described in the detailed description.

DETAILED DESCRIPTION

The core according to the invention may have different weights. The weight of a core is preferably specified in g/m. This signifies the weight of 1 meter of the core.

5 Preferably, this applies to a core with a width from 90 to 110 mm and a material thickness of the board from 0.01 to 1 mm. The material thickness refers to the thickness of the core. The material thickness is sometimes also called "wall thickness".

10 Preferably, the core has a weight of 30 to 70 g/m, more preferably 30 to 60 g/m, more preferably 30 to 55 g/m, even more preferably 30 to 50 g/m, most preferably 30 to 45 g/m. It was found that with a weight in the aforementioned ranges, the core is capable of being transported efficiently even in large volumes and, at the same, time, the core shows good mechanical properties. Further, with a weight in the aforementioned ranges, the core shows a good discharge capacity, even after several months of
15 service.

The core may be shaped using different processing methods. Preferably, the core is shaped by extrusion, more preferably by profile extrusion. This has the advantage that the core can be manufactured in large volumes. Further, the core can be manufactured
20 in a process that is simple to implement. In addition, the core can be manufactured without the use of a lot of machinery.

The composition from which the core is manufactured may comprise further components. The composition may also consist of a polyester comprising one or more
25 hydroxycarboxylic acids as monomers, a copolyester obtained by condensation of at least one diol component and at least one diacid component, and at least 5 wt.% of an inorganic filler, based on the total weight of the composition.

The composition from which the core is manufactured comprises a polyester
30 comprising one or more hydroxycarboxylic acids as monomers. The polyester may consist of one or more hydroxycarboxylic acids as monomers. Preferably, the

hydroxycarboxylic acids independently have 2 to 10 carbon atoms, more preferably 2 to 8 carbon atoms, even more preferably 2 to 6 carbon atoms.

Examples of preferred hydroxycarboxylic acids include lactic acid, glycolic acid, 2-
5 hydroxybutyric acid, 2-hydroxy-2-methylpropanoic acid, 6-hydroxyhexanoic acid, 3-hydroxybutyric acid, 3-hydroxyvaleric acid, and 3-hydroxyhexanoic acid.

If present, all different stereoisomers of the aforementioned monomers may be employed. For example, both D-lactic acid and L-lactic acid may be employed.
10 Preferably, only one stereoisomer is employed. For example, only L-lactic acid may be employed.

The polyester may be obtained by polycondensation of the hydroxycarboxylic acid monomer or hydroxycarboxylic acid monomers. The polyester may also be obtained
15 by other means, for example by ring-opening polymerization. The polyester may also be obtained from natural sources. For example, the polyester may be synthesized by bacteria.

The polyester may be a homopolymer or a copolymer. It is also possible to use a
20 mixture of different polyester polymers comprising one or more hydroxycarboxylic acids as monomers as polyester in the composition from which the core is manufactured.

Accordingly, the polyester is preferably selected from the group consisting of
25 poly(caprolactone), poly(lactic acid), poly(L-lactic acid), poly(3-hydroxybutyrate), poly(3-hydroxyvalerate), poly(3-hydroxyhexanoate), poly(3-hydroxybutyrate-co-3-hydroxyvalerate), poly(3-hydroxybutyrate-co-3-hexanoate), and mixtures thereof, in particular from the group consisting of poly(caprolactone), poly(lactic acid), poly(L-lactic acid), and mixtures thereof. More preferably, the polyester is poly(lactic acid),
30 even more preferably poly(L-lactic acid).

It was found that the aforementioned polyesters, in particular poly(caprolactone), poly(lactic acid), poly(L-lactic acid), and mixtures thereof, allow to manufacture cores with good mechanical properties. Also, with these polyesters, the composition could be processed well.

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The composition may comprise the polyester in different amounts. Preferably, the composition comprises 40 to 75 wt.%, preferably 45 to 70 wt.%, more preferably 50 to 65 wt.%, of the polyester, based on the total weight of the composition.

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It was found that when the composition comprises the polyester in the aforementioned ranges, the melt can be processed by extrusion at acceptable pressures. Further, the core is then degraded in the soil at an acceptable speed, in particular when poly(lactic acid) is used as the polyester.

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The composition further comprises a copolyester comprising at least one diol component and at least one diacid component. The copolyester is preferably obtained by polycondensation of the at least one diol component and the at least one diacid component.

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Preferably the diacid component or the diacid components independently have 2 to 20 carbon atoms more preferably 2 to 16 carbon atoms, even more preferably 2 to 12 carbon atoms, most preferably 2 to 8 carbon atoms. Examples of diacid components include aromatic and/or aliphatic diacids. Particular examples of diacid components include succinic acid, adipic acid, malonic acid, glutaric acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, terephthalic acid, isophthalic acid, phthalic acid, and mixtures thereof. Preferred diacid components are succinic acid, adipic acid, sebacic acid, terephthalic acid, and mixtures thereof.

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Preferably the diol component or the diol components independently have 2 to 20 carbon atoms more preferably 2 to 10 carbon atoms, even more preferably 2 to 8 carbon atoms, most preferably 2 to 6 carbon atoms. Specific examples of diol

components include ethylene glycol, 1,2-propanediol, 1,3-propanediol, 1,2-butanediol, 1,3-butanediol, 1,4-butanediol, 1,5-pentanediol, and mixtures thereof. Butanediol is a preferred diol component.

- 5 From the aforementioned diol components and diacid components, different copolyesters can be obtained. Preferably, the copolyester comprises at least one diol component and at least two diacid components.

Preferably, the copolyester is selected from the group consisting of poly(butylene
10 succinate), poly(butylene sebacate), poly(butylene adipate-co-succinate),
poly(butylene adipate-co-sebacate), poly(butylene adipate-co-terephthalate),
poly(butylene sebacate-co-terephthalate), and mixtures thereof, more preferably from
the group consisting of poly(butylene succinate), poly(butylene adipate-co-
terephthalate), and mixtures thereof. Most preferably, the copolyester is
15 poly(butylene adipate-co-terephthalate).

Use of the aforementioned copolyesters allows to obtain cores with good mechanical properties and good biodegradability.

- 20 The composition may comprise the copolyester in different amounts. Preferably, the composition comprises 15 to 45 wt.%, preferably 20 to 40 wt.%, more preferably 25 to 35 wt.%, of the copolyester, based on the total weight of the composition.

It was found that the core has good mechanical properties when the aforementioned
25 copolyesters are used. Further, the composition is degraded in the soil at an acceptable speed.

The composition further contains an inorganic filler. Different inorganic fillers may be employed. Preferably, the inorganic filler is selected from the group consisting of
30 calcium carbonate, dolomite, talcum, kaolin, mica, and mixtures thereof. More preferably, the inorganic filler is selected from the group consisting of calcium

carbonate, dolomite, talcum, and mixtures thereof. Most preferably, the inorganic filler is calcium carbonate.

5 The inorganic filler may also comprise dolomite and/or calcium carbonate, preferably calcium carbonate, and 12% carbon by weight, based on the weight of the inorganic filler.

10 Preferably, the inorganic filler has an average particle size of 0.5 to 10 μm , preferably 1 to 5 μm , more preferably 1 to 3 μm . Advantageously, the inorganic filler has a particle size distribution wherein 55 wt.% of the particles has a size of 10 μm or smaller, preferably 5 μm or smaller, more preferably 3 μm or smaller, most preferably 2 μm or smaller. The particle size distribution is advantageously determined using a Sedigraph II 5120 Particle Size Analyzer available from Micromeritics.

15 The inorganic filler may have a polished surface, in particular such that no sharp edges remain on the surface of the filler particles. This may be achieved, for example, by filling the inorganic filler particles into a mixing apparatus equipped with a stirring device, wherein the inner walls of the mixing apparatus surface have been treated to provide a rough surface. The stirring device is then rotated at high speed to spin the
20 filler particles against the vertical inner walls of the mixing apparatus. In this way, the filler particles become polished. Subsequently, a binding agent, for example pine ester, in particular with a molecular weight below 10000 g/mol, may be mixed with the polished particles at high speed mixing under heating at a temperature of about 80°C and subsequently cooled.

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The inorganic filler may also be surface treated. For example, the inorganic filler may have a d_{50} in the range from 0.5 to 3.0 μm and a treatment layer on the surface of the inorganic filler comprising a phosphoric acid ester blend of one or more phosphoric acid mono-ester and salty reaction products thereof and/or one or more phosphoric
30 acid di-ester and salty reaction products thereof, and/or at least one saturated aliphatic linear or branched carboxylic acid and salty reaction products thereof,

and/or at least one aliphatic aldehyde and/or salty reaction products thereof, and/or at least one mono-substituted succinic anhydride consisting of succinic anhydride mono-substituted with a group selected from a linear, branched, aliphatic, and cyclic group having a total amount of carbon atoms from at least C₂ to C₃₀ in the substituent and/or salty reaction products thereof, and/or at least one polydialkylsiloxane, and/or mixtures of the aforementioned materials, wherein the inorganic filler comprises the treatment layer in an amount of from 0.1 to 2.3 wt.%, based on the total dry weight of the inorganic filler. The d₅₀ is advantageously determined using a Sedigraph II 5120 Particle Size Analyzer available from Micromeritics.

The composition comprises at least 5 wt.% of the inorganic filler, based on the total weight of the composition. Preferably, the composition comprises 5 to 40 wt.%, preferably 5 to 30 wt.%, more preferably 5 to 20 wt.%, of the inorganic filler, based on the total weight of the composition.

It was found that the core can be shaped by extrusion, in particular by profile extrusion, when the core is manufactured from a composition comprising inorganic filler in the aforementioned ranges. At the same time, despite the presence of the filler in amounts of 5 wt.% or more, based on the total weight of the composition, the resulting cores had good mechanical properties and, in particular, were not very brittle.

Preferably, the composition has a melt flow index MFI, determined according to ISO 1133, in particular ISO 1133-1:2001, 2.16 kg, 190°C, from 5 to 30 g/10 min, preferably from 10 to 25 g/10 min, more preferably from 15 to 20 g/10 min.

It was found that a composition with an MFI in the aforementioned ranges is well processable at acceptable pressures in the extruder.

Preferably, the composition is free from a lubricant. Preferably, the composition is free from polymers that are not biodegradable, in particular from polyethylene and

polypropylene. Preferably, the composition is free from a nucleating agent such as nanoclay.

The core may have different shapes. Preferably, the core is approximately plate-shaped. The core advantageously has at least one, preferably several, channels that extend along the longitudinal direction of the core. Preferably, the channels extend along the entire length of the core. More preferably, the core has 0.5 to 6 channels on one side of the core per cm along the width of the core. The cross-sectional area of one channel is preferably from 1 to 50 mm², more preferably from 1 to 30 mm², even more preferably from 1 to 20 mm². The core preferably has a wall thickness from 0.01 mm to 1 mm.

The shape of the channel is not particularly limited. The channels may have a rectangular shape, a trapezoidal shape, or a sinusoidal shape. Preferably, the core comprises channels with a trapezoidal shape. Preferably, the core contains channels on both sides. The channels on the two sides of the core opening to the top and the bottom may overlap. In this way, two channels form a pair that opens to the top and to the bottom at the same position along the width of the core. The channels on both sides of the core opening to the top and the bottom may also be offset. In this way, the channels open to the top and to the bottom in an alternating fashion along the width of the core. Preferably, the core contains channels on both sides, wherein the channels open to the top and to the bottom in an alternating fashion along the width of the core.

The invention also provides for a process for manufacturing the core of a drain board according to the invention, comprising the steps of

- a. providing a composition comprising
 - i. a polyester comprising one or more hydroxycarboxylic acids as monomers,
 - ii. a copolyester comprising at least one diol component and at least one diacid component,
 - iii. an inorganic filler,

- wherein the composition comprises at least 5 wt.% of the inorganic filler, based on the total weight of the composition,
- b. mixing the composition using thermal and/or mechanical energy,
 - c. shaping of the core.

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The steps of the process are preferably conducted in the aforementioned order.

For the polyester of the process according to the invention, the provisions described above for the polyester concerning the core according to the invention shall apply.

- 10 Further, for the copolyester of the process according to the invention, the provisions described above for the copolyester concerning the core according to the invention shall apply. Moreover, for the inorganic filler of the process according to the invention, the provisions described above for the inorganic filler concerning the core according to the invention shall apply. Further, for the composition of the process according to
- 15 the invention, the provisions described above for the composition concerning the core according to the invention shall apply.

- According to the process of the invention, the composition is mixed using thermal and/or mechanical energy. Thermal energy can for example be applied by heating the
- 20 composition with a heating unit, or by irradiating with a proper irradiation source. Mechanical energy can be applied by mixing using a mixer.

- Preferably, the core is shaped by extrusion. More preferably, the core is shaped by profile extrusion or by extrusion followed by a calendering step. Most preferably, the
- 25 core is shaped by profile extrusion.

- In the process according to the invention, the core is preferably shaped by profile extrusion and a calibration unit cooled to 10 to 30°C, preferably 10 to 25°C, more preferably 10 to 20°C, is used. In the process of the invention, the core is preferably
- 30 cooled after shaping. This may be conducted in different ways. Preferably, the core is cooled using a waterbath.

The invention also provides for a drain board comprising a core according to the invention surrounded by a filter material. The filter material is preferably water-permeable. The filter material serves to block larger soil particles that might block the core channels. In this way, preferably only liquids, in particular aqueous liquids such as water or aqueous solutions, may pass the filter material.

The filter material is preferably made from a biodegradable polyester. More preferably, the filter material is made from a polyester selected from the group consisting of poly(caprolactone), poly(lactic acid), poly(L-lactic acid), poly(3-hydroxybutyrate), poly(3-hydroxyvalerate), poly(3-hydroxyhexanoate), poly(3-hydroxybutyrate-co-3-hydroxyvalerate), poly(3-hydroxybutyrate-co-3-hexanoate), and mixtures thereof, in particular from the group consisting of poly(caprolactone), poly(lactic acid), poly(L-lactic acid), and mixtures thereof, most preferably poly(lactic acid).

The filter material is preferably made from a nonwoven fabric, in particular a spunbonded nonwoven fabric. The nonwoven fabric is preferably made of poly(lactic acid) fibers. The fibers preferably have a fineness of 1 to 10 dtex.

The filter material, in particular the nonwoven fabric, preferably has a basis weight from 30 g/m² to 150 g/m², more preferably from 50 g/m² to 125 g/m², even more preferably from 60 g/m² to 100 g/m². This helps to reduce the overall weight of the drain boards.

In this way, the drain board as a whole may be biodegradable.

The drain board according to the invention may have good discharge capacities. Preferably, the drain board has a discharge capacity from 50 m³/year to 2000 m³/year, more preferably from 100 m³/year to 2000 m³/year, most preferably from 150 m³/year to 1500 m³/year.

The drain boards may be used for several different purposes. The drain boards according to the invention are used for soil improvement, in particular as a horizontal or a vertical drain, as earthquake drain, or as a gas drain.

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EXAMPLES

Materials

- 10 Polycaprolactone, PCL, Daicel Coporation; potato starch, PS, Rodenburg Biopolymers; poly(3-hydroxybutyrate-co-3-hydroxyhexanoate), PHBH, Kaneka Corporation; poly(butylene-adipate-co-terephthalate), PBAT, BASF AG; poly(lactic acid), PLA, NatureWorks LLC; poly(L-lactic acid), PLLA, Total Corbion PLA; wood particles 500 μm , WP, J. Rettenmaier & Söhne GmbH + Co. KG; calcium carbonate, CaCO_3 , Omya
15 International AG.

The following mixtures were compounded at 170 °C to 230 °C to yield blends Blend-1 to Blend-5 using the above-identified materials with a twin-screw extruder with an L/D ratio of more than 25. Unless stated otherwise, all amounts are in weight-%

- 20 (wt.%). Blend-3 was not compounded.

Table 1: Mixtures

	Blend-1*	Blend-2*	Blend-3*	Blend-4*	Blend-5
PCL	41	-	-	-	-
PS	27	-	-	-	-
PHBH	-	-	100	-	-
PBAT	-	60	-	50	28
PLA	-	40	-	40	-
PLLA	-	-	-	-	57
WP	-	-	-	20	-
CaCO ₃	32	-	-	-	15
MFI	15	n.d.	n.d.	n.d.	17

Explanation to Table 1: MFI – melt flow index (ISO 1133-1:2001, 2.16 kg, 190°C) in g/10 min; * – Blend-1 to Blend-4 are comparative examples; n.d. – not determined.

- 5 The blends Blend-1 to Blend-5 were subsequently used to prepare drain cores with a corrugated shape by profile extrusion.

For this purpose, a single-screw extruder with an L/D ratio of 30 was used. The extruder was equipped with a tool to extrude a core of a drain board with a regular

10 corrugated profile. The extrusion equipment also comprised a calibration unit and a waterbath for cooling. The aforementioned tool and calibration unit are designed to yield with polyolefins at 22 to 28 m/min and a pressure of less than 500 bar as well as an energy consumption of less than 65% iE (determined as ratio between actual

15 drain boards with a weight of 40 to 60 g/m, a width of 9.9 cm, a height of 2 mm, and a cross-sectional area of an individual trapezoidal channel of about 5 mm², wherein a core contains a total of 38 channels over its width. The following processing parameters were used.

Table 2: Temperature profile extruder using a corrugated tool

Zone 1 to 3	Zone 4 to 6	Tool
80 °C to 160 °C	170°C to 180 °C	170°C to 180°C

Rotational speed 40 to 60 rpm

Throughput 45 to 75 kg/h

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The blends Blend-1 to Blend-5 yielded the following results upon extrusion compiled in Table 3.

Table 3:

Blend	P	EC	W	Wi	Sh	Th	Process
Blend-1	++	++	++	0	0	-	0
Blend-2	++	++	++	0	-	0	0
Blend-3	+	0	nc*	--	-	-	-
Blend-4	++	++	++	+	-	0	0
Blend-5	0	0	0	0	0	0	0

- 10 Explanations for Table 3: P – pressure in kPa in the extruder during extrusion measured with a Graff Melt pressure sensor: 0 = 200-250 kPa, + = 251-350 kPa, ++ = 351-450 kPa, +++ = more than 450 kPa; EC – energy consumption in %iE during extrusion determined as the ratio between the actual motor current and the maximum motor current of the extruder; 0 = 45-55 %iE, + = 56-60 %iE, ++ = 61-65 %iE, +++ = more than 65 %iE; W – weight in g/m of the core at which an acceptable shape (height from 1-3 mm, regular shape) was obtained: 0 = 40-50 g/m, + = 51-60 g/m, ++ = 61-80 g/m, +++ = more than 80 g/m, nc* – Blend-3 did not yield a core of a drain board because the material was too flexible after melting and did not keep the shape of the core, the material was also very brittle after 24 h; Wi – width in mm: -- = less than 90 mm, - = less than 95 mm, 0 = 95-105 mm, + = more than 105 mm; Sh – Shape, assessed visually in terms of symmetrical shape of the channels and proper formed edges and a regular wall thickness: - = not acceptable, 0 = good; Th – Throughput assessed qualitatively as fast enough throughput at an acceptable core weight: -- = too low, - =
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low, 0 = ok; process assessed as 0 = ok and having a strong stable flow without unmelted resin/particles and almost no breakage of the line during the run with the melt not being sensitive for vibrations in all directions, - = not ok and missing at least one of the aforementioned properties.

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Well-shaped cores were obtained for Blend-5 in particular when using a water-cooled calibration unit at 10 °C to 20 °C.

10 The core of a drain board made from Blend-5 with a width of 100 mm was enclosed in a filter material to yield a drain board. The discharge capacity of this drain board when used as vertical drain was tested according to EN 15237:2007, apparatus 2. The tensile strength of this drain board when used as vertical drain was tested according to EN ISO 10319:2015. For this purpose, a spunbonded nonwoven fabric (basis weight 90 g/m², thickness from 250-350 µm) made of only polylactic acid fibers (melting
15 point 170°C, fiber fineness 5 dtex) was wrapped around the cores of the drain boards and fixed by welding the overlapping fabric. The results are compiled in Table 4.

Table 4: Discharge capacity and tensile strength

Core material	DC	TS
Blend-5	2-50	1.3-1.7

20 Explanations to Table 4: DC – discharge capacity as vertical drain in ml/s for a 100 mm wide core of a drain board determined according to EN 15237:2007, apparatus 2; TS – tensile strength in kN determined according to EN ISO 10319:2015.

25 As can be seen from the data in the tables above, vertical drains from biodegradable materials with good performance can be obtained from a blend comprising a polyester obtained by condensation of one or more hydroxycarboxylic acids such as poly(lactic acid), a copolyester obtained by condensation of at least one diol component and at least one diacid component such as PBAT and an inorganic filler such as calcium carbonate. This allows the manufacture of a core of a drain board with a good and regular shape with acceptable processing parameters.

The resulting vertical drain shows a good discharge capacity. The drain was also found to have a sufficiently long service time.

- 5 From the data in the tables above, it also appears that the profile extrusion into the particular shapes of the cores of vertical drains, which is important for good performance, cannot be achieved with acceptable process conditions when one of the components is missing.