

Method for recovering land along coastlines

Description

- 5 The recovery of land along sea coasts has long been important for the settlement of areas or for opening up areas for utilization. Thus, by recovering land along the seas areas which in the course of time can be put to agricultural use or even settled are obtained. As in the past, this is of considerable importance particularly in regions with a sharply growing population for creating living space and bases for nutrition. Further-
10 more, the recovery of land in the region of coasts and estuaries makes an important contribution to coastal protection.

- By recovering land, dry areas which constitute a protection in case of flooding can be provided in front in settled areas. Moreover, the washing away of regions close to the
15 coast is a major problem in many regions which can be solved by the recovery of off-shore land areas.

- In general, land is recovered from seas with substantial tides substantially by a system comprising platforms, mud dams, interwoven fencing and brush fences which are in-
20 stalled so that water at least partly flows around them at high tide and they are present outside the sea at ebb tide. The mud dams divide the foreshore in a field-like manner and leave narrow passages for the inflowing and outflowing water masses, which are passed into lateral ditches. As a result, the water is calm and flowing away at ebb tide is delayed. In the calm water, more sediment, also referred to as silt, then settles on
25 the bottom of the sea. When the high tide escapes back, the material which has become silt then gradually settles on the platforms and fences so that the land is gradually raised. When the bottom of the sea reaches the height of the high tide, ditches are excavated and silt is distributed over the land for a further increase. Fresh sediments can again settle in the ditches. The newly recovered land is as a rule dammed for pro-
30 tection.

- In another method, instead of utilizing the natural silting by the sea in land recovery, a retaining dike is first constructed in the water, within the limits of which dike tides no longer prevail. Thereafter, the annular dikes are constructed and, at ebb tide, the water
35 is removed with the aid of a pumping station. This leads to land recovery in shorter times than in Germany.

- The erection of structures comprising wastes, for example municipal garbage, is furthermore known, which structures should then lead to settlement of sediments under-
40 water.

DD 222 070 describes a method for coastal protection and for earth fill in which anchored fences of fascines comprising corrosion-resistant rings connected to one another, in particular beaded rings of vehicle tires, are deployed, in which the sediments

are deposited. However, these apparatuses have insufficient stability and are difficult to produce.

5 In JP 17590070, blocks of garbage are surrounded by sheets of synthetic resins or wire netting and are introduced in this way for land recovery in coastal strips.

DE 38 42 668 describes a method for land recovery in which stable plastic is removed from garbage, defibered, converted into slurry with binder and sand and placed behind previously set sheet piling.

10 A disadvantage of this method is that the garbage also comprises environmentally harmful substances which can lead to contamination of the corresponding coastal sections. Moreover, moldings produced from garbage are inhomogeneous and hence unstable owing to the different composition of the garbage.

15 DE 34 38 204 describes an apparatus for covering coasts with sand. This consists of an artificial reef which is composed of prefabricated structural elements. A bedding layer of steel netting is deployed on the bottom of the sea and equipped with prefabricated elements which rest like bridges on the steel netting.

20 WO 03/021046 describes a net-like platform for land recovery, which is fastened to the bottom by means of fastening elements.

25 WO 2002/092917 A1 describes a porous platform for land recovery which consists of a screen standing on a plurality of posts and having various orifices. The screen may consist of PE, PP, other polymers and polymer blends.

30 It was an object of the invention to provide a method for recovering land which is simple in construction, has particularly high mechanical stability and in addition can be specifically adapted by different cavities to various flow conditions.

The object could surprisingly be achieved if land recovery is effected using apparatuses which comprise at least one porous composite of stones and plastics which are arranged so that water flows over them at least from time to time.

35 The invention relates to a method for recovering land by means of apparatuses, around and/or over at least some of which water flows at least from time to time, wherein the apparatuses comprise a porous composite of stones and plastics.

40 At least some of the apparatuses for land recovery are arranged transversely to the main direction of flow of the water.

In addition, further apparatuses can be arranged substantially longitudinally relative to the main direction of flow of the water so that the area is divided in a field-like manner. The structures arranged substantially longitudinally relative to the main direction of flow of the water may likewise be the porous moldings but also solid walls and/or netting. It may be advantageous if passages are additionally present in the apparatuses arranged transversely to the main direction of flow of the water, through which passages part of the water can flow away. This prevents the water from becoming backed up in the fields.

10 The apparatuses according to the invention can be arranged as usual in the recovery of land. In one embodiment, they can therefore be arranged in a field-like manner, in the form of closed or interrupted structures arranged substantially transversely to the main direction of flow of the water or irregularly.

15 If the apparatuses are designed as interrupted structures, it is preferable to connect them to one another by suitable structural elements, for example clamps and/or bridges, in particular those comprising metal. It is also possible to arrange a plurality of rows of interrupted moldings one behind the other. In this arrangement, it is preferable if, behind the gap in a row, a molding is arranged in the next row.

20 The apparatuses used according to the invention must be mounted in every case so that water flows over or around them at least from time to time. The flowing over and/or flowing around can take place as a result of the movement of the waves. In coastal sections with tides, the apparatuses are mounted so that they are present outside the water at ebb tide and at least partly within the water at high tide.

25 The waves or the high tide flow or flows over the apparatuses. Since the porous composites of stones and plastics are water-permeable, water present on the land side can flow through them. After flowing over the apparatuses, the water is calmed. In the process, the sediments settle.

The porous moldings preferably have a thickness in the range from 20 cm to 2 m.

35 The water-permeable moldings may have a perpendicular, wall-like profile.

In another embodiment of the invention the water-permeable moldings have an oblique profile ascending or descending at any desired angle. They can have a profile which is oblique in the direction of the sea side and descends in the direction of the sea side and a profile which is perpendicular in the direction of the land side or a profile which descends in the direction of the land side and is perpendicular in the direction of the sea side.

The porous composites of stones and plastics comprise stones which are bound to one another with a plastic. The plastics may be, for example, polyurethanes, epoxy resins, unsaturated polyester resins, acrylates and methacrylates. Polyurethane is preferably used.

5

The stones generally have a size of from 1 to 50 cm, preferably from 1 to 20 cm, particularly preferably from 2 to 15 cm, in particular from 2.5 to 6.5 cm. The stones are preferably crushed rock.

10

It may be advantageous if the size of the stones changes within the molding. Preferably, the size of the stones will become larger or smaller from the land side to the sea side and/or from bottom to top, depending on the flow conditions.

15

The stones are bound firmly to one another by the plastic only at their contact surfaces. Thus, the composite body is porous and the water can flow into the interior of the molding.

20

The stones are covered only superficially with the plastic. The layer of the plastic on the stone is generally only a few millimeters, preferably not more than 5 mm, in particular from 0.1 to 5 mm, thick. As a result, only a small amount of plastic is required for the composite body. Nevertheless, the bond between the stones and the plastic is so strong that it also withstands considerable stress.

25

Since the water can flow into the porous composite, the energy with which the water strikes the composite body is better absorbed by the escape of the water into cavities and therefore does not lead to destruction of the molding even under considerable stress. Moreover, the strength of the waves is greatly reduced thereby.

30

The size of the stones used and hence also the pore size of the composites depend in particular on the respective flow conditions. Structures in which the size of the cavities through which flow is possible varies within an element are also possible.

35

The platforms, dikes and/or mud dams may consist exclusively of the composites of stones and plastics.

40

In a further embodiment, the composite body is present on a base, for example of concrete or masonry.

The composites used according to the invention can be produced in various ways.

In the simplest case, the stones are poured loosely in the desired position and in the desired shape and size and the liquid starting components for the plastic are applied to them, where they cure.

If the composite body is mounted on a foundation, the foundation is first let into the bottom. This can be effected in a customary and known manner.

- 5 The composite body is mounted on the structure so it cannot be removed from its position by the waves. In the simplest case, this can be effected as described above. It is also possible to erect platforms, dikes and/or mud dams provided with gaps and to introduce the composites into the gaps.

- 10 In all cases, it is possible, as described above, first to create a loose bed of the stones, to which the liquid starting components of the plastic are applied, for example by spraying or pouring, where they cure to give the plastic.

- 15 In a preferred embodiment of the method according to the invention the stones are mixed with the liquid starting components of the plastics and then applied to the desired position, where the plastic cures.

- 20 In principle, all types of mixers by means of which substantially complete wetting of the stones with the liquid starting components of the plastic is possible can be used as a mixer for mixing the loose stones with the starting components of the plastic. Mixers which consist of an open container, for example a drum, which is preferably provided with internals, have proven to be particularly suitable. For the mixer, either the drum can be rotated or the internals can be moved.

- 25 Mixtures of this type are known and are used, for example, in the construction industry for the production of concrete mixers.

- If the mixture is applied directly to the surface to be consolidated, it may be advantageous to mount the mixer on a vehicle, for example a tractor, a front loader or a truck.
30 In this embodiment of the method according to the invention, the mixture can be transported in each case to the place where it is to be applied. After the mixture has been emptied, the mixture can be distributed manually, for example by means of rakes.

- 35 In one embodiment of the method according to the invention, the mixing of the stones with the liquid starting components of the plastic is effected continuously. For this purpose, the stones and the liquid starting components of the plastic are introduced continuously into the mixer and the wetted stones are discharged continuously. In this procedure, it must be ensured that the starting materials remain in the mixer long enough so that sufficient wetting of the stones can take place. Expediently, such a mixer apparatus can be moved along the sections to be consolidated at a speed such that the
40 stones wetted with the liquid starting components of the plastic are discharged from the mixer in the amount required for the consolidation. It is also possible to operate the

continuous apparatus while stationary and to transport the wetted stones discharged from the mixer to the desired location.

5 In a further embodiment of the continuous design of the method according to the invention, the mix may be a rotating drum into which stones are continuously introduced. This drum is equipped with nozzles which distribute the starting components of the plastic continuously over the stones. Here, the rotation of the drum ensures thorough mixing of plastic and stones. Plastic/stone composites are then discharged continuously through an orifice at the end of the drum. The rotating drum may be horizontal
10 but may also be inclined at various angles in order to promote the discharge.

In a further embodiment of the continuous method, the stones are transported continuously on a conveyor belt which is moved through a tunnel. The latter has orifices via which the starting materials of the plastic are discharged continuously onto the stones.
15 At the end of the conveyor belt, the stones then fall into an opening mixing drum which discharges the composite at an adjustable transport speed.

In another embodiment of the method according to the invention, the composites are produced as moldings and these are applied in the desired positions.
20

The production of the composite bodies can likewise be carried out in various ways.

In the production of these moldings, the mixture of the stones with the liquid starting components of the plastic is introduced into a mold which is preferably open at the top, where the plastic cures. The moldings preferably have a size such that they can be
25 transported without problems and can be applied to the foundation. In particular, the size is in the range of 100 + 50 x 100 + 50 x 15 + 10 cm.

In the production of the moldings, the stones can be introduced into the mold and the liquid starting components of the plastics can be applied to this bed. There, they wet the surface of the stones and cure to give the finished plastic. In a preferred embodiment of the production, the stones are mixed with the liquid starting components of the plastics in a mixing apparatus and the stones wetted in this manner are introduced into the mold, where they cure to give the molding. The advantages of this embodiment are
30 firstly the better mixing; secondly, moldings having a greater thickness can be produced. The time for the mixing should be at least so long that the stones are wetted as completely as possible with the liquid mixture and at most so long that the plastic has not cured. Moreover, it is also possible to use those stones which have loosely adhering impurities on their surface. As a result of the mechanical stress during the mixing
35 process, these impurities are removed from the surface of the stones and thus can no longer adversely affect the adhesion of the stones to one another.
40

The platforms, dikes and/or mud dams can be differently designed depending on the flow conditions.

5 Thus, the structures may have a straight, wall-like profile or an oblique profile ascending or descending at any desired angle. Thus, the structures may have an oblique profile on the sea side and a straight profile on the land side, or vice versa.

Plastics which may be used are the polymers described above. In order to achieve good long-term stability, the plastics should be rendered hydrophobic.

10

Preferably used plastics are polyurethanes and epoxy resins.

In a preferred embodiment of the invention, in particular compact polyurethanes can be used as plastics.

15

Regarding the preferably used polyurethanes, the following may be stated.

In the context of the present invention, components of the polyurethanes are understood very generally as meaning compounds having free isocyanate groups and compounds having groups which are reactive with isocyanate groups. Groups which are reactive with isocyanate groups are generally hydroxyl groups or amino groups. Hydroxyl groups are preferred since the amino groups are very reactive and the reaction mixture therefore has to be processed rapidly. The products formed by reaction of these components are referred to below generally as polyurethanes.

25

In neither of the two process variants is it necessary for the stones to be present in dry form. Surprisingly, good adhesion between the polyurethane and the stones can be obtained also when wet stones are present and even underwater.

30 The polyurethanes used may be the conventional and known compounds of this type. The preparation of these materials is effected by reacting polyisocyanates with compounds having at least two reactive hydrogen atoms. Polyisocyanates which can be used are in principle all polyisocyanates, mixtures and prepolymers having at least two isocyanate groups, which are liquid at room temperature.

35

These may be aliphatic isocyanates, for example hexamethylene diisocyanate (HDI), isophorone diisocyanate (IPDI) or the reaction products thereof with themselves, for example with incorporation of uretdione or isocyanurate groups.

40 Aromatic polyisocyanates are preferably used, particularly preferably isomers of toluylene diisocyanate (TDI) and of diphenylmethane diisocyanate (MDI), in particular mixtures of MDI and polyphenylenepolyethylene polyisocyanates (crude MDI). The polyisocyanates may also be modified, for example by the incorporation of iso-

cyanurate groups and in particular by the incorporation of urethane groups. The last-mentioned compounds are prepared by reacting polyisocyanates with less than the stoichiometric amount of compounds having at least two active hydrogen atoms and are usually referred to as NCO prepolymers. Their NCO content is in general in the
5 range from 2 to 29% by weight.

In general, polyfunctional alcohols, so-called polyols, or, less preferably, polyfunctional amines are generally used as compounds having at least two hydrogen atoms reactive with isocyanate groups.

10 In a preferred embodiment of the method according to the invention, the polyurethanes used are compact polyurethanes, in particular those which have been rendered hydrophobic. The hydrophobicity can be achieved in particular by addition of hydroxyl-functional components customary in fat chemistry to at least one of the starting compo-
15 nents of the polyurethane system, preferably to the polyol component.

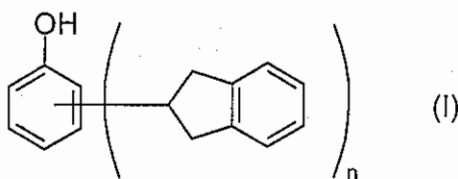
A number of hydroxyl-functional components customary in fat chemistry are known and can be used. Examples are castor oil, oils modified with hydroxyl groups, such as grapeseed oil, black cumin oil, pumpkin seed oil, borage seed oil, soybean oil, wheat
20 germ oil, rapeseed oil, sunflower oil, peanut oil, apricot seed oil, pistachio oil, almond oil, olive oil, macadamia nut oil, avocado oil, sea buckthorn oil, sesame oil, hazelnut oil, evening primrose oil, wild rose oil, hemp oil, thistle oil, walnut oil, fatty acid esters modified with hydroxyl groups and based on myristoleic acid, palmitoleic acid, oleic acid, vaccenic acid, petroselinic acid, gadoleic acid, erucic acid, nervonic acid, linoleic acid,
25 linolenic acid, stearidonic acid, arachidonic acid, timnodonic acid, clupanodonic acid or cervonic acid. Castor oil and its reaction products with alkylene oxides or ketone/formaldehyde resins are preferably used here. The last-mentioned compounds are sold, for example, by Bayer AG under the name Desmophen® 1150.

30 A further preferably used group of polyols customary in fat chemistry can be obtained by ring opening of epoxidized fatty acid esters with simultaneous reaction with alcohols and, if appropriate, subsequent further transesterification reactions. The incorporation of hydroxyl groups into oils and fats is effected in the main by epoxidation of the olefinic double bond present in these products, followed by the reaction of the epoxide groups
35 formed with a monohydric or polyhydric alcohol. The epoxide ring is converted into a hydroxyl group or, in the case of polyfunctional alcohols, a structure having a larger number of OH groups. Since oils and fats are generally glyceryl esters, simultaneous transesterification reactions take place during the abovementioned reactions. The compounds thus obtained preferably have a molecular weight in the range from 500 to
40 1500 g/mol. Such products are available, for example, from Henkel.

In a particularly preferred embodiment of the method according to the invention, the compact polyurethane used is one which can be prepared by reacting polyisocyanates

with compounds having at least two hydrogen atoms reactive with isocyanate groups, wherein the compounds having at least two reactive hydrogen atoms comprise at least one polyol customary in fat chemistry and at least one aromatic hydrocarbon resin modified with phenol, in particular an indene/coumarone resin. These polyurethanes and their components have such a high hydrophobicity that they can in principle even cure under water.

Preferably used phenol-modified aromatic hydrocarbon resins having a terminal phenol group are phenol-modified indene/coumarone resins, particularly preferably industrial mixtures of aromatic hydrocarbon resins, in particular those which comprise, as a substantial component, compounds of the general formula (I)



where n is from 2 to 28. Such products are commercially available and are offered, for example, by Rütgers VFT AG under the trade name NOVARES®.

The phenol-modified aromatic hydrocarbon resins, in particular the phenol-modified indene/coumarone resins, generally have an OH content of from 0.5 to 5.0% by weight.

Preferably, the polyol customary in fat chemistry and the phenol-modified aromatic hydrocarbon resin, in particular the indene/coumarone resin, are used in a weight ratio of from 100:1 to 100:50.

Together with said compounds, further compounds having at least two active hydrogen atoms can be used. Owing to their high stability to hydrolysis, polyether alcohols are preferred. These are prepared by conventional and known processes, generally by an addition reaction of alkylene oxides with H-functional initiator substances. The concomitantly used polyether alcohols preferably have a functionality of at least 3 and a hydroxyl number of at least 400 mg KOH/g, preferably at least 600 mg KOH/g, in particular in the range from 400 to 1000 mg KOH/g. They are prepared in a conventional manner by reacting at least trifunctional initiator substances with alkylene oxides. Initiator substances which can be used are preferably alcohols having at least three hydroxyl groups in the molecule, for example glycerol, trimethylolpropane, pentaerythritol, sorbitol or sucrose. The preferably used alkylene oxide is propylene oxide.

Further conventional constituents, for example catalysts and conventional assistants and additives, can be added to the reaction mixture for the preparation of the polyurethanes. In particular, drying agents, for example zeolites, should be added to the reaction mixture in order to avoid the accumulation of water in the components and hence

foaming of the polyurethanes. These substances are preferably added to the compounds having at least two hydrogen atoms reactive with isocyanate groups. This mixture is frequently referred to in industry as polyol component. For improving the long-term stability of the composites, it is furthermore advantageous to add agents for preventing attack by microorganisms. Moreover the addition of UV stabilizers is advantageous for avoiding embrittlement of the moldings.

The polyurethanes used can in principle be prepared without the presence of catalysts. For improving the curing, catalysts may be concomitantly used. Catalysts selected should preferably be those which result in as long a reaction time as possible. This makes it possible for the reaction mixture to remain liquid for a long time. It is possible in principle, as described, also to work entirely without catalyst.

The combination of the polyisocyanates with the compounds having at least two hydrogen atoms reactive with isocyanate groups should be effected in a ratio such that a stoichiometric excess of isocyanate groups, preferably of at least 5%, in particular in the range from 5 to 60%, is present.

The preferably used hydrophobic polyurethanes are distinguished by particularly good processability. Thus, these polyurethanes exhibit particularly good adhesion, in particular to moist substrates, such as wet rock, in particular crushed rock. The curing of the polyurethanes takes place to give a virtually compact product, in spite of the presence of water. The compact polyurethanes used also exhibit completely compact curing even in the case of thin layers.

By rendering the plastics hydrophobic the hydrolytic degradation thereof is effectively suppressed. The apparatuses according to the invention can remain in place after the land recovery. They thereby make a contribution to the consolidation of the land area recovered and thus serve for coastal protection.

We claim:-

1. An apparatus for recovering land along coastlines, which consists of arrangements which comprise at least one water-permeable molding, the water-permeable molding consisting of stones bound to one another by means of plastic.
2. The apparatus according to claim 1, wherein the moldings are arranged in such a way that seawater flows over them at least from time to time and at least part of the water then flows back into the sea through the molding.
3. The apparatus according to claim 1, wherein the moldings are arranged on foundations in the bottom.
4. The apparatus according to claim 1, wherein the water-permeable moldings are present completely underwater from time to time.
5. The apparatus according to claim 1, wherein the water-permeable moldings are present partly underwater.
6. The apparatus according to claim 1, wherein the water-permeable moldings are arranged continuously.
7. The apparatus according to claim 1, wherein the water-permeable moldings are arranged so as to be spatially separated and connected to one another by structural elements.
8. The apparatus according to claim 1, wherein the water-permeable moldings have a perpendicular, wall-like profile.
9. The apparatus according to claim 1, wherein the water-permeable moldings have an oblique profile ascending or descending at any desired angle.
10. The apparatus according to claim 1, wherein the water-permeable moldings have, in the direction of the sea side, an oblique profile descending in the direction of the sea side and, in the direction of the land side, a perpendicular profile.
11. The apparatus according to claim 1, wherein the water-permeable moldings have, in the direction of the land side, a profile descending in the direction of the land side and, in the direction of the sea side, a perpendicular profile.
12. The apparatus according to claim 1, which runs substantially transversely to the main direction of flow of the water.

13. The apparatus according to claim 1, wherein, in addition to the apparatuses running substantially transversely to the main direction of flow of the water, apparatuses running longitudinally relatively to the main direction of flow of the water are installed so that the bottom is divided in a field-like manner.

5

14. The apparatus according to claim 1, wherein the moldings have a thickness in the range of from 20 cm to 2 m.