Preventing or reducing plant growth by biocementation

The present invention primarily relates to the use of a mixture capable of biocementation as a means of preventing or reducing plant growth, preferably weed growth, on/in a substrate. The invention also relates to a method for preventing or reducing plant growth, preferably weed growth, on/in a substrate.

Further aspects and preferred forms of the present invention result from the following explanations, the attached examples and in particular the attached patent claims.

The uncontrolled growth of weeds is a constant problem in agriculture, in cities and municipalities and in the area of home gardens, as it leads to yield losses in agriculture and is perceived as very disturbing and unattractive on paths and other surfaces. For this reason, weeds are combated and/or destroyed by thermal methods such as flaming, manual weeding by hand or with the aid of various tools or chemical agents. However, it can currently be observed that more and more resistancies are being developed against many of the existing products and they must therefore be used repeatedly, which further increases the cost of their use. In addition, the treated areas are quickly repopulated by uncontrolled seed inflow.

It was therefore the primary object of the present ~~invention~~ disclosure to provide a means for preventing or reducing unwanted plant growth that would overcome the above problems.

According to the ~~invention~~disclosure, this primary object is solved by using a mixture capable of biocementation as a means for preventing or reducing (through the processes of biocemention, respectively) plant growth, preferably weed growth.

According to one aspect, the present disclosure provides a use of a mixture capable of biocementation as a means for preventing or reducing plant growth, preferably weed growth.

According to another aspect, the present disclosure provides a method for preventing or reducing plant growth, preferably weed growth, on/in a substrate consisting of or comprising the following steps:

(a) Identifying a substrate to be treated on/in which plant growth, preferably weed growth, is to be prevented or reduced,

(b) providing a mixture as defined herein,

(c) applying and/or introducing the mixture provided in step (b) onto/into the substrate to be treated in an amount sufficient to enable biocementation, and

(d) forming a biocement layer so that plant growth or weed growth on/in the substrate is prevented or reduced.

In the context of the present text, the term biocementation stands for an essentially natural solidification and/or hardening of (permeable) substrates (as defined below in the context of the method according to the invention). This prevents or reduces plant growth on/in these substrates. Biocement within the scope of this text is the product of the biocementation as defined herein.

According to a preferred embodiment, said essentially natural solidification and/or hardening is a process in which parts of the substrate on/in which plant growth is to be reduced or prevented are bound together by one or more binders contained in the mixture to be used according to the invention and/or formed from its components, thereby effecting solidification and/or hardening (biocementation) of the substrate or parts of the substrate. According to a particularly preferred embodiment, said natural solidification and/or

Patent claims:

1. Use of a mixture capable of biocementation as a means for preventing or reducing plant growth, preferably weed growth.

2. Use according to claim 1, wherein the mixture comprises or consists of one or more organisms and/or enzymes.

3. Use according to claim 1 or 2, wherein the mixture comprises or consists of the following components:

   (i) one or more organisms and/or enzymes capable of forming carbonate and/or of inducing and/or catalyzing carbonate formation,

   (ii) one or more substances for the formation of carbonate,

   (iii) optionally: one or more cation sources; and

   (iv) optionally: one or more additives.

4. Use according to claim 2 or 3, wherein the organism or organisms, if applicable in component (i), of the mixture is/are one organism/several organisms which, when assay A comprising the following steps is carried out

   Assay A

   (i) providing and contacting an organism to be characterised or a mixture of organisms to be characterised, one or more substances for the formation of carbonate and optionally further substances and optionally a substrate,

   (ii) providing a means for detecting a ureolysis and/or carbonate formation,

   (iii) combining the mixture resulting from step (i) with the means from step (ii), and

   (iv) determining from the means from step (ii) whether a ureolysis and/or carbonate formation is present,

   leads to the detection of a ureolysis and/or carbonate formation in step (iv), preferably - if a substrate has been provided - the detection of biocementation, preferably one that is sufficient to prevent or reduce plant growth, preferably the growth of weed.

5. Use according to any of the preceding claims, wherein the mixture is present in liquid form, as a gel, paste or powder.

6. Use according to any of the claims 2 to 5, wherein one or the, several or all organism(s) is/are selected from the group consisting of microorganisms, preferably is/are selected from the group consisting of microorganisms of the phylum Firmicutes, preferably of the class Bacilli, preferably of the order Bacillales, preferably of the families Planococcaceae or Bacillaceae, preferably of the genera *Sporosarcina*, *Lysinibacillus* or *Bacillus*, preferably selected from the species *Sporosarcina pasteurii*, *Sporosarcina ureae*, *Lysinibacillus sphaericus*, *Lysinibacillus fusiformis*, *Bacillus megaterium*, *Lysinibacillus* sp., *Bacillus pseudofirmus*, *Bacillus halodurans* or *Bacillus cohnii*; and microorganisms of the phylum Proteobacteria, preferably of the classes Alphaproteobacteria, Gammaproteobacteria, Deltaproteobacteria or Epsilonproteobacteria, preferably of the orders Enterobacteriales, Myxococcales, Campylobacterales, Pseudomonadales or Caulobacterales, preferably of the families Enterobacteriaceae, Myxococcaceae, Helicobacteraceae, Pseudomonadaceae or Caulobacteraceae, preferably of the genera *Proteus*, *Myxococcus*, *Helicobacter*, *Pseudomonas* or *Brevundimonas*, preferably selected from the species *Proteus vulgaris*, *Proteus mirabilis*, *Myxococcus xanthus*, *Helicobacter pylori*, *Pseudomonas aeruginosa* or *Brevundimonas diminuta*; and microorganisms of the phylum Actinobacteria, preferably of the class Actinobacteria, preferably of the order Actinomycetales, preferably of the families Brevibacteriaceae or Micrococcineae, preferably of the genera *Brevibacterium* or *Micrococcaceae*, preferably selected from the species *Brevibacterium linens* or *Arthrobacter crystallopoietes*; and microorganisms of the phylum Cyanobacteria, preferably of the class Cyanobacteria, preferably of the order Synechococcales, preferably of the family Synechococcaceae, preferably of the genus *Synechococcus*, preferably of the species *Synechococcus*; and aerobic bacteria, anaerobic bacteria, facultative anaerobic bacteria and their intermediates.

7. Use according to any of the claims 2 to 6, wherein one or the, several or all enzymes is/are selected from the group consisting of urease, asparaginase, carbonic anhydrase and metabolic enzymes.

8. Use according to any of the claims 3 to 7, wherein one or the, several or all substances for the formation of carbonate is/are selected from the group consisting of urea and salts thereof, organic acids such as lactic acid and salts thereof, preferably carboxylates, and esters thereof, gluconic acid and salts thereof, preferably carboxylates, and esters thereof, acetic acid and salts thereof, preferably carboxylates, and esters thereof, formic acid and salts thereof, preferably carboxylates, and esters thereof, peptides, preferably containing asparagine, glutamine and/or glutamic acid, amino acids, preferably asparagine, glutamine and glutamic acid, and salts thereof, preferably carboxylates, and esters thereof, vegetable and animal complex substrates, in particular peptone, yeast extract, meat extract, nutrient broth and casamino acid, industrial waste

streams, in particular maize steep liquor, lactose mother liquor, protein lysates, preferably from peas, meat or tomatoes, anaerobic substrates, preferably carbon dioxide and methane.

9. Use according to any of the claims 3 to 8, wherein one or the, several or all cation sources is/are selected from the group consisting of organic and inorganic calcium salts, preferably calcium nitrate, calcium acetate, calcium lactate and calcium chloride, magnesium salts, manganese salts, zinc salts, cobalt salts, nickel salts, copper salts, lead salts, iron salts, cadmium salts, polymers, preferably cationic polymers, heavy metal cations, light metal cations, radioactive cations and mixtures thereof.

10. Use according to any of the claims 3 to 9, wherein one or the, several or all of the additives is/are selected from the group consisting of nutrients; (bio-)polymers, preferably polyhydroxybutyrate, polylactide, polybutylene succinate, polyacrylic acid, polymethacrylate, poly(2-hydroxyethylmethacrylate), polyvinyl alcohol, polyvinyl acetate, polyvinylpyrrolidone, poly(2-ethyl-2-oxazoline), polystyrene, polyamide, copolymers, polyamino acids, cellulose and derivatives thereof, starch and derivatives thereof, lignins and derivatives thereof, pectins and derivatives thereof, natural adhesives, in particular gum arabic, latex, rubber and derivatives thereof, chitin and derivatives thereof, chitosan and derivatives thereof, cyclodextrins and derivatives thereof, dextrins and derivatives thereof; hydrogel formers, preferably xanthan gum, alginates and agar agars; cold soluble and/or warm soluble (plant) glues; calcium carbonates and mixtures containing calcium carbonates, preferably mother-of-pearl, amorphous calcium carbonates, precipitated calcium carbonate, aragonite, calcite, vaterite and mixtures and derivatives thereof; polysaccharides and extracellular polymeric substances (EPS), preferably microbial exopolysaccharides, preferably containing or consisting of maleic acid, acetic acid, lactic acid, lactose, sucrose, glucose, fructose and/or inulin; protein sources, fibres and fibrous materials, preferably casein, albumin, yeast extracts, peptones, cellulose fibres, wood fibres, wood cellulose fibres; residues and industrial materials, preferably maize steep liquor, lactose mother liquor, protein lysates, molasses, protein waste, preferably from yeast production, meat production, dairy industry and paper production; silicates and derivatives thereof; acrylates and derivatives thereof; water glasses and water glass-like binders; cements and cement additives, preferably sand, lime and derivatives thereof, aluminium oxide, calcium oxide, calcium hydroxide, aluminium hydroxide, ash, preferably fly ash and bone ash, microsilica, kaolins, bentonites, filling materials, preferably white lime (hydrate), limestone crushed sand and limestone powder; resins and epoxides; natural and chemical herbicides; fungicides; molluscicides; insecticides; hydrophobizers and wax emulsions; emulsifiers; binders; thixotropic agents; crystallization nuclei and crystallization modifiers; fatty acids; minerals and trace elements; salts, preferably phosphates and sulphates; rocks, preferably pumice stone and slate powder; bacteria capable of forming polymers; and substance(s) modifying the biocementation.

11. Use according to any of the claims 1 to 10, wherein the plant or weed is selected from the group consisting of dicotyls of the genera: *Abutilon, Aegopodium, Aethusa, Amaranthus, Ambrosia, Anachusa, Anagallis, Anoda, Anthemis, Aphanes, Arabidopsis, Atriplex, Barbarea, Bellis, Bidens, Bunias, Capsella, Carduus, Cassia, Centaurea, Chenopodium, Chrysanthemum, Cirsium, Conium, Conyza, Consolida, Convolvulus, Datura, Descurainia, Desmodium, Emex, Equisetum, Erigeron, Erodium, Erysimum, Euphorbia, Fumaria, Galeopsis, Galinsoga, Galium, Geranium, Heracleum, Hibiscus, Ipomoea, Kochia, Lamium, Lapsana, Lathyrus, Lepidium, Lithoserpermum, Linaria, Lindernia, Lycopsis, Malva, Matricaria, Mentha, Mercurialis, Mullugo, Myosotis, Papaver, Pharbitis, Plantago, Polygonum, Portulaca, Ranunculus, Raphanus, Rorippa, Rotala, Rumex, Salsola, Senecio, Sesbania, Sida, Sinapis, Sisymbrium, Solanum, Sonchus, Sphenoclea, Stachys, Stellaria, Taraxacum, Thlaspi, Trifolium, Tussaligo, Urtica, Veronica, Viola, Xanthium*; dicotyls of the genera: *Arachis, Beta, Brassica, Cucumis, Cucurbita, Helianthus, Daucus, Glycine, Gossypium, Ipomoea, Lactuca, Linum, Lycopersicon, Nicotiana, Phaseolus, Pisum, Solanum, Vicia*; monocotyls of the genera: *Aegilops, Agropyron, Agrostis, Alopecurus, Apera, Avena, Brachiaria, Bromus, Cenchrus, Commelina, Cynodon, Cyperus, Dactyloctenium, Digitaria, Echinochloa, Eleocharis, Eleusine, Eragrostis, Eriochloa, Festuca, Fimbristylis, Heteranthera, Imperata, Ischaemum, Juncus, Leptochloa, Lolium, Monochoria, Panicum, Paspalum, Phalaris, Phleum, Poa, Rottboellia, Sagittaria, Scirpus, Setaria, Sorghum*; and monocotyls of the genera: *Allium, Ananas, Asparagus, Avena, Hordeum, Oryza, Panicum, Saccharum, Secale, Sorghum, Triticale, Triticum, Zea*; mosses of the lineages liverworts, hornworts, mosses (Bryopsida);

    preferably wherein the growth of at least two, three, four, five, six, seven, eight, nine, ten, more than ten or all of these plants is prevented or reduced.

12. Use according to any of the preceding claims, wherein the biocement layer formed has a water coefficient of permeability of greater than 10^{-9} to 10^{0} m/s, preferably greater than 10^{-9} to 10^{-3} m/s, further preferably greater than 10^{-8} to 10^{-3} m/s.

13. Use according to any of the claims 1 to 12, wherein the biocementation reaction is not an exothermic reaction.

14. Method for preventing or reducing plant growth, preferably weed growth, on/in a substrate consisting of or comprising the following steps:

    (a) Identifying a substrate to be treated on/in which plant growth, preferably weed growth, is to be prevented or reduced,

    (b) providing a mixture as defined in any of the claims 1 to 10,

(c) applying and/or introducing the mixture provided in step (b) onto/into the substrate to be treated in an amount sufficient to enable biocementation, and

(d) forming a biocement layer so that plant growth or weed growth on/in the substrate is prevented or reduced.

15. Method according to claim 14, wherein the substrate is selected from the group consisting of sand, soil, preferably land soil and plant soil, humus, crushed stone, gravel, clay, silt, sawdust, paper, cardboard, chipboard, softwood, limestone, coal and mixtures thereof.

16. ~~A method~~Method according to claim 14 or 15, wherein the plant or weed is selected from the group consisting of dicotyls of the genera: *Abutilon, Aegopodium, Aethusa, Amaranthus, Ambrosia, Anachusa, Anagallis, Anoda, Anthemis, Aphanes, Arabidopsis, Atriplex, Barbarea, Bellis, Bidens, Bunias, Capsella, Carduus, Cassia, Centaurea, Chenopodium, Chrysanthemum, Cirsium, Conium, Conyza, Consolida, Convolvulus, Datura, Descurainia, Desmodium, Emex, Equisetum, Erigeron, Erodium, Erysimum, Euphorbia, Fumaria, Galeopsis, Galinsoga, Galium, Geranium, Heracleum, Hibiscus, Ipomoea, Kochia, Lamium, Lapsana, Lathyrus, Lepidium, Lithoserpermum, Linaria, Lindernia, Lycopsis, Malva, Matricaria, Mentha, Mercurialis, Mullugo, Myosotis, Papaver, Pharbitis, Plantago, Polygonum, Portulaca, Ranunculus, Raphanus, Rorippa, Rotala, Rumex, Salsola, Senecio, Sesbania, Sida, Sinapis, Sisymbrium, Solanum, Sonchus, Sphenoclea, Stachys, Stellaria, Taraxacum, Thlaspi, Trifolium, Tussaligo, Urtica, Veronica, Viola, Xanthium*; dicotyls of the genera: *Arachis, Beta, Brassica, Cucumis, Cucurbita, Helianthus, Daucus, Glycine, Gossypium, Ipomoea, Lactuca, Linum, Lycopersicon, Nicotiana, Phaseolus, Pisum, Solanum, Vicia*; monocotyls of the genera: *Aegilops, Agropyron, Agrostis, Alopecurus, Apera, Avena, Brachiaria, Bromus, Cenchrus, Commelina, Cynodon, Cyperus, Dactyloctenium, Digitaria, Echinochloa, Eleocharis, Eleusine, Eragrostis, Eriochloa, Festuca, Fimbristylis, Heteranthera, Imperata, Ischaemum, Juncus, Leptochloa, Lolium, Monochoria, Panicum, Paspalum, Phalaris, Phleum, Poa, Rottboellia, Sagittaria, Scirpus, Setaria, Sorghum*; and monocotyls of the genera: *Allium, Ananas, Asparagus, Avena, Hordeum, Oryza, Panicum, Saccharum, Secale, Sorghum, Triticale, Triticum, Zea*; mosses of the lineages liverworts, hornworts, mosses.

17. ~~A process~~Method according to any of the claims 14 to 16, wherein the mixture is present in liquid form, as a gel, paste or powder.

18. Method according to any of the claims 14 to 17, wherein the biocement layer formed has a water coefficient of permeability of greater than 10^{-9} to 10^{0} m/s, preferably greater than 10^{-9} to 10^{-3} m/s, further preferably greater than 10^{-8} to 10^{-3} m/s.

19. Method according to any of the claims 14 to 18, wherein the formation of a biocement layer in step (d) of the method does not comprise an exothermic reaction.