

Description

The present invention is directed to an article of manufacture useful for the containment of water over a predetermined land area and for the treatment of any water that permeates the containment area so that water permeating a water-holding layer of the article of manufacture is simultaneously treated for removal or neutralization of one or more water-soluble contaminants.

Various polymers, swellable clays, and articles of manufacture have been applied to the surface of soil to provide a waterproofing layer to prevent substantial penetration of water and hazardous or toxic materials into the earth in order to provide lagoons, ponds and hazardous or toxic waste containment areas. Water-swellable clays, such as bentonite, have been applied directly to the soil surface and impacted in place, as disclosed in this assignee's prior Patent No. 3,986,365. In addition, many different multi-layered articles of manufacture containing a water-swellable clay, such as bentonite, have been manufactured by adhesively securing the water-swellable clay to a flexible sheet material for application to the soil surface in abutting or overlapping relation of adjoining multi-layered articles. Examples of flexible sheet materials containing adhesively secured water-swellable clays are found in the following U.S. patents: Clem 4,467,015; Clem 4,501,788; McGroarty et al 4,693,923; Harriett 4,656,062; and Harriett 4,787,780.

Another waterproofing barrier disclosed in Elias U.S. Patent No. 4,344,722 is constructed in the field by applying a first flexible, water-permeable fabric layer, overlaying a thickness of powdered or granular water-swellable clay material and applying an upper or overlayer of the same flexible, water-permeable fabric thereover. Other patents disclosing the use of substantially water-impermeable layers for protecting a soil surface include British Patent Specification 1,059,363; British Patent Specification 1,029,513 and British Patent Specification 1,129,840.

As set forth in this assignee's U.S. Patent No. 4,094,382, water-soluble industrial wastes, particularly at relatively high concentrations, can substantially increase the water-permeability of water-swellable clays, such as bentonite. Thus, when the water barrier characteristics of a water-swellable clay is most important - that is, when used to contain a substantially contaminated pond, lagoon or hazardous or toxic waste containment area, oftentimes the clay allows seepage of a substantial amount of the contaminated solution into the soil, sometimes resulting in contamination of valuable ground water supplies.

Attempts have been made to prevent the seepage of contaminated water through the water-swellable clay so that the contaminants would not find their way into ground water supplies. An example of an attempt to improve the water barrier characteristics of water-swellable clays when subjected to a head of water contaminated with water-soluble inorganic industrial contaminants include this assignee's U.S. Patent No. 4,084,382. WO 83/01204 describes a method for preventing escape of organic contaminant material, comprising the steps of: collecting the organic waste material at a waste disposal site; substantially containing and preventing release of hazardous organic waste material from the waste disposal site; and sorbing substantially all of the hazardous organic waste material passing from the waste disposal site in an organoclay to substantially prevent escape of the hazardous organic waste material to the environment.

In brief, the present invention is directed to an article of manufacture and method for holding and treating water contaminated with one or more water-soluble contaminants to substantially prevent the contaminants from seeping into ground water supplies disposed below a water holding area. The article of manufacture and method of the present invention include the use of a water-holding material, e.g., a water-swellable clay, such as bentonite, for reducing the permeation of the contaminated water into the soil, and an in-ground treatment layer containing a material capable of adsorbing, absorbing, ion-exchanging, neutralizing or reacting with one or more water-soluble contaminants within the water for removing a substantial portion of the contaminants from the water so that the portion of the held water that permeates the water-holding layer, will be rendered substantially less contaminated.

Accordingly, an object of the present invention is to provide a new and improved article of manufacture and method for reducing the permeation of water-soluble contaminants into ground water supplies.

According to one aspect of the invention there is provided a water holding area for containment and treatment of contaminated water comprising an earthen depression capable of retaining water having a soil floor permeable to water; a contaminant-treating material disposed above the soil floor and capable of treating a contaminant in said water upon contact to reduce the concentration of the contaminant in said contacted water; a layer of water-holding material disposed above the contaminant-treating material, and a layer of water-permeable sheet material disposed between the contaminant-treating material and the water-holding material, said water-holding material capable of al-

lowing permeation of contaminated water therethrough, at a predetermined rate for treatment by said contaminant-treating material and a layer of water-permeable sheet material on the outer surface of each of the water-holding material and the contaminant treating material.

Preferably the contaminant treating material is prepared as a structurally stable layer of treating material between lower and upper layers of water-permeable sheet material and wherein the layer of water-holding material is disposed on the upper layer of water-permeable sheet material and further includes another layer of water-permeable sheet material on an upper surface of said layer of water-holding material. More preferably the layer of contaminant-treating material is disposed between two layers of water-permeable sheet material, and wherein the layer of water-holding material is disposed between two other layers of water-permeable sheet material.

According to a second aspect of the invention there is provided a method for containing contaminated water held in an earthen water-holding area and for treating water that permeates a water-holding material disposed proximate to a soil floor portion of the water-holding area for removal or neutralization of a contaminant therein, comprising applying above the soil floor of the water-holding area a multilayer article of manufacture including a layer of contaminant-treating material disposed below a layer of water-holding material having a layer of water-permeable sheet material therebetween and a layer of water permeable sheet material on the outer surface of each of the water holding material and the contaminant treating material, said contaminant-treating material capable of treating the containing contaminated water that penetrates the water-holding material to reduce the contaminant concentration of water that passes through the contaminant-treating material, and said water-holding material capable of allowing permeation of contaminated water therethrough at a predetermined rate for treatment by said contaminant-treating material.

Preferably the method comprises preparing a contaminant-treating material as a structurally stable layer of treating material between fabric sheets and preparing a water-holding material as a structurally stable layer of water-holding material between two other fabric sheets, said water-holding material capable of slowing the permeation of contaminated water through the soil floor, applying the layer of treating material above the soil floor, and applying the layer of water-holding material above the treating layer to form the earthen water-holding area, said contaminant treating material capable of treating the contaminated water that penetrates the water-holding material to reduce the contaminant

concentration of water that passes through the contaminant-treating material.

According to a fourth aspect of the invention there is provided an article of manufacture for use in containment and treatment of contaminated water, comprising a contaminant-treating material, said material being capable of treating a contaminant in said water upon contact to reduce the concentration of the contaminant in said contacted water; a layer of water-holding material, said water-holding material capable of allowing permeation of contaminated water therethrough, at a predetermined rate for treatment by said contaminant-treating material, a layer of water-permeable sheet material disposed between the contaminant-treating material and the water-holding material, and a layer of water permeable sheet material on the outer surface of each of the water holding material and the contaminant treating material.

Preferably two layers of water-permeable sheet material are disposed between said layer of contaminant-treating material and said layer of water-holding material.

Use of the present invention may result in one or more of the following:

- (i) an article of manufacture and method for reducing both the amount of water-permeating a soil and the amount of contaminants in the permeating water to improve the quality of ground water supplies.
- (ii) a device and method for removing contaminants from a water supply by first substantially slowing the permeation of water into a soil surface with a water-holding material, such as a water-swellaable clay material, e.g. bentonite clay, and thereafter treating only the water permeating the water-holding material to remove one or more contaminants therefrom.
- (iii) an article of manufacture and method for holding contaminated water in a holding pond or lagoon, and preventing the contaminants from permeating the soil by containing the water with a non-biodegradable water-holding material, such as by contacting the water with a water-swellaable clay, to substantially slow the penetration rate of the contaminated water, and contacting the water that penetrates the water-holding material with an adsorbent, absorbent ion-exchange material or a reactant for one or more inorganic or organic contaminants in the water to substantially reduce the amount of contaminants reaching ground water supplies.

In accordance with the present invention, an article of manufacture made in accordance with the present invention includes a water-holding layer, such as a layer of a water-swellaable clay, such as bentonite, for the purpose of holding a quantity of water within an earthen holding area for containing

a body of water containing one or more water-soluble contaminants. The article of manufacture, in addition to providing the water-barrier characteristics, also provides a material capable of treating one or more of the water-soluble contaminants to remove or neutralize one or more contaminants.

In accordance with an important feature of the present invention, the article and method of the present invention unexpectedly provides the capability of neutralizing or removing the contaminants only from that portion of the held water that permeates the water-holding layer so that only that portion of the held water that presents a problem, that is - only the water that permeates the water-holding layer, is treated for removal of the undesirable contaminants.

The water-holding layer of the article and method of the present invention can be any material capable of holding a head of water at a desired permeation rate. Environmental specifications generally call for a material having a water permeation rate of 1×10^{-7} cm/sec or less. Suitable materials include sheet materials and fabrics having the desired permeability. Suitable fabrics include woven and non-woven permeable fabrics made from polypropylene, polyesters, nylon, propylene-ethylene copolymers, polypropylene-polyamide copolymers, and the like. The geotechnical fabrics are preferred for their bacteriological and chemical resistance. The thickness of the fabric is not important and such fabrics generally are available in thicknesses of 3 to about 30 mils.

Other suitable water-holding materials include a layer of water swellable clay, such as the bentonite compositions disclosed in this assignee's prior patents Nos. 4,810,573; 4,733,989; 4,656,062; 4,534,926 and 4,534,925, which patents are hereby incorporated by reference. Preferred is a layer of a water-swellable colloidal clay, such as bentonite.

Preferably, the water-swellable colloidal clay that can be utilized as the water barrier material of the articles of the present invention is any water-swellable colloidal clay which will hydrate in the presence of water, i.e., will swell in the presence of water. In accordance with one important embodiment of the present invention, the colloidal clay is bentonite. A preferred bentonite is sodium bentonite which is basically a hydratable montmorillonite clay of the type generally found in the Black Hills region of South Dakota and Wyoming. This clay has sodium as a predominant exchange ion. However, the bentonite utilized in accordance with this embodiment of the present invention may also contain other cations such as magnesium and iron. There are cases wherein a montmorillonite predominant in calcium ions can be converted to a high swelling sodium variety through a well known process called "peptizing". The colloidal clay uti-

lized in this invention may be one or more peptized bentonites. The colloidal clay may also be any member of the dioctahedral or trioctahedral smectite group or mixtures thereof. Examples are Beidellite, Nontronite, Hectorite and Saponite. To achieve the full advantage of the present invention, the colloidal clay, e.g., bentonite, generally is finely divided as known for use in water barrier panels and the like, i.e, 150 to 350 mesh.

In accordance with an important feature of the present invention, in addition to the water barrier characteristics, the articles of the present invention further include the capability of neutralizing or removing one or more water-soluble contaminants from the water that permeates the water-holding layer to clarify the water that passes through the soil and into any ground water supply that might be present beneath the soil surface.

Some of the most prevalent contaminants found in waste waters contained in ponds, lagoons and other water-holding areas, particularly where these water-holding areas include industrial waste waters, are heavy metal ions and water-soluble organic materials. Water-insoluble organic materials, particularly those resulting from industrial waste, are easily removed at some point prior to the industrial waste water being placed in a water-holding area. It is well known in the prior art that natural and synthetic zeolites are capable of removing a substantial portion of the heavy metal ions from a waste water solution and that organophilic clays are capable of removing water-soluble organic materials from solution. However, the prior art suggests that removal of these materials from waste water streams should be done on stream, treating the entirety of the waste water stream in order to remove these materials. Because of the massive amounts of industrial waste water treated when treated on stream, the treatment material, e.g., zeolite and/or organophilic clay, must be frequently replaced because of the heavy volumes of water water stream that passes through the zeolites or passes through the organophilic clays in order to clarify these waste water streams.

In accordance with an important embodiment of the present invention, the contaminant removal or neutralizing layer, comprising any contaminant adsorbent, absorbent, ion-exchange material, reactant, or contaminant neutralizing material is supplied as a separate layer below the layer of water-holding material so that the amount of material treated for the removal of contaminants is only that material which completely permeates the water-holding layer.

In accordance with another important advantage of the article of manufacture and process of the present invention, the volume of contaminated water held in water-holding earthen structure will

become increasingly concentrated in contaminants with time, as water evaporates from the water-holding area. When the water held in the water-holding area becomes so contaminated that the water-holding ability of the water-swella-
 5 ble clay is substantially reduced after a number of months or years, the entire water-holding area can be solidified, such as with silicate cementing agent, e.g., U.S. Patent No. 3,837,872, hereby incorporated by reference, and cemented over and a new water-holding area formed with a clean contaminant re-
 10 moving layer and a clean water-swella-
 15 ble clay layer or other water-holding material layer and the process repeated. Alternatively, the concentrated, ex-
 20 ceptionally contaminated water held in the water-holding area after a period of years can be pumped from the water-holding area and disposed of in any suitable landfill or treated on stream in a continuous process for removal of contaminants while the layers of contaminant-treating material, e.g., the zeolite and/or organophilic clay and the layer of water-holding material are removed and replaced.

In accordance with another important feature of the present invention, the contaminant neutralizing or removal material mixed with the water-swella-
 25 ble clay, as shown in FIG. 1, or supplied as a separate layer, as shown in FIG. 2, can be any material capable of adsorbing, absorbing, ion-exchanging, or reacting with the contaminants for removal, such as by insolubilization, or for neutralization while keeping the contaminant(s) water-soluble, in order to decrease the toxicity of or remove the con-
 30 taminants from absorbed in the soil below the water-holding area.

Examples of materials capable of removing or neutralizing contaminants that are present in the water held in the water-holding areas of FIGS. 1 and 2 include absorbents including absorbent fi-
 35 bers such as microcrystalline cellulose; attapulgite clay; zinc rincingleate absorbed on an absorbent fiber or other absorbent or adsorbent material; amorphous silica powder; synthetic calcium silicate; polyolefin pulp; sodium aluminosilicate (e.g., sodium zeolites); multodextran; sodium silica aluminates, and the like. Such absorbents can be utilized as a separate layer beneath the water-holding material layer, or can be mixed into the water-absorbent clay composition layer, preferably homogeneously. Other materials capable of removing or neutralizing contaminants include adsor-
 40 bents, such as microcrystalline cellulose; silica hydrogel based compositions; attapulgites; synthetic sodium magnesium silicates; synthetic calcium silicates; silicon dioxide; acid activated clays; carbon; activated carbons, e.g., activated charcoal; diatomaceous earth, Fuller's earth; zeolites; and the like. Like the absorbents and any other treatment materials, the adsorbents can be provided as a

separate layer or mixed with the water-swella-
 45 ble clay layer. In order to make sure that ground water supplies are not contaminated by any water passing through the water-holding material layer and the layer of treatment material, an algicide, anti-microbial material, bactericide, disinfectant, and/or fungicide can be added to the treatment material layer so that harmful algae, bacteria or fungi do not reach ground water supplies. Suitable materials include phenol; zinc undecylenate N.F.; acetyl
 50 tyridinium chloride N.F.X.III and the like.

Suitable ion exchange materials include sulfonated polystyrene, cross-linked 1% to about 20%; sulfonated phenolic resins; phenol methylene sulfonic acid resin; cellulose alkyl sulfonic acid resins; sulfonated coal; cross-linked acrylic and methacrylic polymers and copolymers; phenolic phosphonic acid resins; aluminum silicate; zirconium phosphate; zirconium tungstate; zirconium molybdate; carboxylated celluloses, e.g., carboxymethyl cellulose; cross-linked trimethyl benzyl ammonium polystyrene matrix; e.g., cross-linked DOWEX and AMBERITE resins; dimethylhydroxyethyl-benzyl ammonium polystyrene, e.g.,
 25 DOWEX and ZEOLEX; phenolic resin matrix condensation products, e.g., IMACS-3, LEWATIT MN and WOFATIT L165; aminopolystyrene; aminated polyacrylic polymers and copolymers; aminated phenolic resin condensation products, e.g., AMBERLITE IR-48, and DUOLITE A-7; epoxy polyamine resins; zirconium oxide gel; aminoethyl cellulose; diethylaminoethylcellulose; epoxy polyamines; amino polystyrene; and aminated phenolic resins, e.g., DUOLITE A-2.

Most preferred as the adsorbent, absorbent ion-exchange and/or reactant and/or neutralizing material are natural or synthetic zeolites and/or organophilic clays. Organophilic clay is basically a montmorillonite clay that has been reacted with a quaternary amine to make it hydrophilic and absorb-
 40 ent to organic contaminants.

The organophilic clays are well known in the art and the most widely used are the alkyl ammonium bentonites, alkylaryl ammonium bentonites and alkylaryl ammonium hectorites containing about 8 to about 32 carbon atoms and being either straight or branched chains. Polar activators some-
 45 times called polar dispersants can be included with (absorbed by) the organophilic clays in an amount of about 10% to about 40% based on the dry weight of the organophilic clay to help separate clay platelets for better organic contaminant absorption. Suitable polar activators include acetone; aqueous methanol or aqueous ethanol, e.g., 75-
 50 98% by weight methanol or ethanol and 2-25% by weight water; and propylene carbonate. It is understood that any organophilic clay capable of absorbing organic contaminants contained in the pond,

lagoon or other waste water contaminant area can be used as the organophilic clay in accordance with the principles of this embodiment of the present invention.

The zeolites useful in accordance with the present invention can be any zeolite capable of absorbing, adsorbing, heating with an ion-exchanging with a containment in the water that reaches the zeolite layer. Generally, zeolites are used for their capability of ion exchanging sodium from the zeolite for a heavy metal contained in waste water. For example, synthetic zeolite Na-A is excellent for removal of Pb^{+2} , Ag^{+} , Cu^{+2} , Cd^{+2} , Zn^{+2} , Co^{+2} , Ni^{+2} and Mn^{+2} , in decreasing order of effectiveness. Synthetic zeolites Na-X and Na-Y are known for removal of Cd^{+2} and La^{+3} .

Generally, Na, K, and/or Ca are used to enrich the natural zeolite for more effective ion exchange and for more ion exchange of more heavy metals. Natural zeolites, such as Na-exchanged clinoptilolite ($Na_6(AlO_2)_6(SiO_2)_{30-24} H_2O$), also are capable of removing heavy metal ions according to the following order of decreasing efficiency: Pb^{+2} , NH_4^{+} , Ba^{+2} , Cu^{+2} , Cd^{+2} , Sr^{+2} , Zn^{+2} , Co^{+2} , Ni^{+2} and Hg^{+2} . Other suitable natural zeolites and other natural clay minerals include tobermorites, hydroxypapetites, and the like.

The invention will now be further described by way of example with reference to the accompanying drawings, in which:-

Fig. 1 is a side view of one embodiment of the article of the present invention including separate layers of a water-swellaable clay and a lower, contaminant removing material, such as a zeolite or an organophilic clay;

Fig. 2 is a view similar to Fig. 1 showing another embodiment of the article of the present invention including a layer of a water holding material, such as bentonite and two contaminant-removing layers disposed below the water holding material;

Fig. 3 is a side view of the article of Fig. 1 installed in a tank farm environment to prevent ground water contamination in case of a tank leak.

Turning now to the drawings and initially to FIG. 1, there is illustrated one embodiment of the article of manufacture of the present invention, generally designated 12, disposed above a soil surface 13 and beneath a holding pond or lagoon 14 to prevent ground water contamination. The holding pond or lagoon 14 generally is formed as a depression in an earthen surface and may contain a layer of soil 16 directly beneath the contaminated liquid 18 to prevent rupture or other disturbance of the multi-layer article of manufacture of the present invention. The soil layer 16, however, generally is unnecessary in forming the holding pond or lagoon

to prevent ground water contamination in accordance with the principles of the present invention. The multi-layer article of manufacture 12, includes an upper layer of woven or non-woven textile material 26 which is water-permeable, and a second layer of a water-swellaable colloidal clay, (such as bentonite) 28, and a lower layer of contaminant treating material 30 disposed directly beneath the layer of water-swellaable colloidal clay 28. The layers of water-swellaable colloidal clay 28 and the contaminant treating material 30 are held together with a lower layer of woven or non-woven textile material 32. A layer of woven or non-woven textile material 34, is disposed intermediate the layers of water swellaable material 28 and contaminant treating material 30. The textile materials 32 and 34 are water-permeable. The layer of water-swellaable colloidal clay 28 will swell upon contact with water to provide a water holding layer and that portion of the contaminated water which passes through the clay layer 28 will be treated with the treating layer 30 for neutralization or removal of contaminants therefrom so that the water that passes completely through the article of manufacture 12 and into the ground water supply will not contaminate the water supply. If desired, an uppermost sheet of water-impermeable sheet material, such as high density polyethylene (not shown) can be applied on top of the textile material 26 to provide an additional or safety layer of water-impermeability.

Fig. 2 shows another embodiment of the multi-layer article of manufacture, generally designated 14 including an upper layer of woven or non-woven textile material 36 which is water permeable; a layer of water-swellaable colloidal clay, such as bentonite 38, and, disposed below the colloidal clay layer 38, two layers of contaminant treating materials for the purpose of neutralization or removal of two different contaminants contained in the contaminated water 18, such as a zeolite layer 40 and an organophilic clay layer 42. The water holding layer 38 and the contaminant treating layers 40 and 42 are structurally held together with a lower layer of woven or non-woven textile material 44 with optional intermediate layers of textile material 46 and 48 for manufacturing purposes. The textile layers 36, 44, 46 and 48 are water-permeable.

In accordance with another important embodiment of the present invention, as shown in FIG. 3, the multi-layer article of manufacture shown in FIG. 1 or Fig. 2 can be applied in the environment of a tank farm so that any spills resulting from tanks, including materials which are undesirable in a ground water supply can be neutralized or removed prior to their reaching the ground water 50 as shown in FIG. 3, the article of manufacture of FIG. 1, generally designated 12 is disposed beneath a four inch layer of stone 52 and above a

layer of native soil 54 that separates the ground water supply 50 from the article of manufacture 12 of the present invention. Any spills that pass through the stone cover layer 52 and through an optional soil layer 56 will be held above the ground water supply by the article of manufacture 12 and any contaminated material that passes through the water holding layer 28 will be treated by the contaminant treating material layer 30 for neutralization or removal of the contaminants before that water passes into the ground water supply 50.

Claims

1. A water holding area for containment and treatment of contaminated water (18) comprising an earthen depression capable of retaining water having a soil floor (13) permeable to water; a contaminant-treating material (30) disposed above the soil floor and capable of treating a contaminant in said water upon contact to reduce the concentration of the contaminant in said contacted water; a layer of water-holding material (28) disposed above the contaminant-treating material, and a layer of water-permeable sheet material (34) disposed between the contaminant-treating material (30) and the water-holding material (28), said water-holding material (28) capable of allowing permeation of contaminated water there through, at a predetermined rate for treatment by said contaminant-treating material (30) and a layer of water permeable sheet material (32, 36) on the outer surface of each of the water-holding material (28) and the contaminant-treating material (30).
2. A water holding area as claimed in claim 1, in which the contaminant-treating material (30) is prepared as a structurally stable layer of treating material between lower and upper layers of water-permeable sheet material (32,34) and wherein the layer of water-holding material (28) is disposed on the upper layer of water-permeable sheet material and further includes another layer of water-permeable sheet material (26) on an upper surface of said layer of water-holding material.
3. A water holding area as claimed in claim 2, wherein the layer of contaminant-treating material is disposed between two layers of water-permeable sheet material, and wherein the layer of water-holding material is disposed between two other layers of water-permeable sheet material.
4. A water holding area as claimed in claim 1, 2 or 3, in which the contaminant treating material (30) is a zeolite or an organophilic clay.
5. A water holding area as claimed in claim 4, in which the contaminant treating material (30) is a montmorillonite clay reacted with a quaternary amine capable of rendering the montmorillonite clay adsorptive or absorptive to organic compounds.
6. A water holding area as claimed in claim 1, 2 or 3, in which the contaminant treating material (30) is selected from the group consisting of a contaminant adsorbent, a contaminant absorbent, a contaminant reactant, a contaminant ion exchange material and a contaminant neutralizing agent.
7. A water-holding area as claimed in any one of the preceding claims, characterised in that the water-holding material (28) comprises a water-swellaable clay.
8. A water holding area as claimed in any one of the preceding claims, characterised in that the water-permeable sheet material (34) comprises a fabric sheet material.
9. A water-holding area as claimed in any one of the preceding claims characterised in that the water holding material (28) has a water permeability of 1×10^{-7} cm/sec or less.
10. A method for containing contaminated water (18) held in an earthen water-holding area and for treating water that permeates a water-holding material disposed proximate to a soil floor portion of the water-holding area for removal or neutralization of a contaminant therein comprising applying above the soil floor of the water-holding area a multilayer article of manufacture including a layer of contaminant-treating material (30) disposed below a layer of water-holding material (28) having a layer of water-permeable sheet material therebetween (34) and a layer of water permeable sheet material (32, 36) on the outer surface of each of the water-holding material (28) and the contaminant-treating material (30), said contaminant-treating material (30) capable of treating the contaminated water that penetrates the water-holding material (28) to reduce the contaminant concentration of water that passes through the contaminant-treating material (30), and said water-holding material (28) capable of allowing permeation of contaminated water therethrough at a predetermined rate for treat-

layer of native soil 54 that separates the ground water supply 50 from the article of manufacture 12 of the present invention. Any spills that pass through the stone cover layer 52 and through an optional soil layer 56 will be held above the ground water supply by the article of manufacture 12 and any contaminated material that passes through the water holding layer 28 will be treated by the contaminant treating material layer 30 for neutralization or removal of the contaminants before that water passes into the ground water supply 50.

Claims

1. A water holding area for containment and treatment of contaminated water (18) comprising an earthen depression capable of retaining water having a soil floor (13) permeable to water; a contaminant-treating material (30) disposed above the soil floor and capable of treating a contaminant in said water upon contact to reduce the concentration of the contaminant in said contacted water; a layer of water-holding material (28) disposed above the contaminant-treating material, and a layer of water-permeable sheet material (34) disposed between the contaminant-treating material (30) and the water-holding material (28), said water-holding material (28) capable of allowing permeation of contaminated water there through, at a predetermined rate for treatment by said contaminant-treating material (30) and a layer of water permeable sheet material (32, 36) on the outer surface of each of the water-holding material (28) and the contaminant-treating material (30).
2. A water holding area as claimed in claim 1, in which the contaminant-treating material (30) is prepared as a structurally stable layer of treating material between lower and upper layers of water-permeable sheet material (32, 34) and wherein the layer of water-holding material (28) is disposed on the upper layer of water-permeable sheet material and further includes another layer of water-permeable sheet material (26) on an upper surface of said layer of water-holding material.
3. A water holding area as claimed in claim 2, wherein the layer of contaminant-treating material is disposed between two layers of water-permeable sheet material, and wherein the layer of water-holding material is disposed between two other layers of water-permeable sheet material.
4. A water holding area as claimed in claim 1, 2 or 3, in which the contaminant treating material (30) is a zeolite or an organophilic clay.
5. A water holding area as claimed in claim 4, in which the contaminant treating material (30) is a montmorillonite clay reacted with a quaternary amine capable of rendering the montmorillonite clay adsorptive or absorptive to organic compounds.
6. A water holding area as claimed in claim 1, 2 or 3, in which the contaminant treating material (30) is selected from the group consisting of a contaminant adsorbent, a contaminant absorbent, a contaminant reactant, a contaminant ion exchange material and a contaminant neutralizing agent.
7. A water-holding area as claimed in any one of the preceding claims, characterised in that the water-holding material (28) comprises a water-swellaable clay.
8. A water holding area as claimed in any one of the preceding claims, characterised in that the water-permeable sheet material (34) comprises a fabric sheet material.
9. A water-holding area as claimed in any one of the preceding claims characterised in that the water holding material (28) has a water permeability of 1×10^{-7} cm/sec or less.
10. A method for containing contaminated water (18) held in an earthen water-holding area and for treating water that permeates a water-holding material disposed proximate to a soil floor portion of the water-holding area for removal or neutralization of a contaminant therein comprising applying above the soil floor of the water-holding area a multilayer article of manufacture including a layer of contaminant-treating material (30) disposed below a layer of water-holding material (28) having a layer of water-permeable sheet material therebetween (34) and a layer of water permeable sheet material (32, 36) on the outer surface of each of the water-holding material (28) and the contaminant-treating material (30), said contaminant-treating material (30) capable of treating the contaminated water that penetrates the water-holding material (28) to reduce the contaminant concentration of water that passes through the contaminant-treating material (30), and said water-holding material (28) capable of allowing permeation of contaminated water therethrough at a predetermined rate for treat-



ment by said contaminant-treating material.

11. A method as claimed in claim 10, comprising preparing a contaminant-treating material as a structurally stable layer of treating material between fabric sheets and preparing a water-holding material as a structurally stable layer of water-holding material between two other fabric sheets, said water-holding material capable of slowing the permeation of contaminated water through the soil floor, applying the layer of treating material above the soil floor, and applying the layer of water-holding material above the treating layer to form the earthen water-holding area, said contaminant treating material capable of treating the contaminated water that penetrates the water-holding material to reduce the contaminant concentration of water that passes through the contaminant-treating material.

12. A method as claimed in claim 10 or 11, in which the contaminant treating material (30) is a zeolite or an organophilic clay.

13. A method as claimed in claim 12, in which the contaminant treating material (30) is a montmorillonite clay reacted with a quaternary amine capable of rendering the montmorillonite clay adsorptive or absorptive to organic compounds.

14. A method as claimed in claim 10 or 11, in which the contaminant treating material (30) is selected from the group consisting of a contaminant adsorbent, a contaminant absorbent, a contaminant reactant, a contaminant ion exchange material and a contaminant neutralizing agent.

15. A method as claimed in any one of claims 10 to 14, in which the water-holding material (28) comprises a water-swellaable clay.

16. A method as claimed in claim 14, in which the water holding material (28) has a water permeability of 1×10^{-7} cm/sec or less.

17. An article of manufacture for use in containment and treatment of contaminated water, comprising a contaminant-treating material (30), said material being capable of treating a contaminant in said water upon contact to reduce the concentration of the contaminant in said contacted water; a layer of water-holding material (28), said water-holding material capable of allowing permeation of contaminated water therethrough, at a predetermined rate for

treatment by said contaminant-treating material, a layer of water-permeable sheet material (34) disposed between the contaminant-treating material and the water-holding material, and a layer of water permeable sheet material (32, 26) on the outer surface of each of the water holding material (28) and the contaminant treating material (30).

18. An article of manufacture as claimed in claim 17, wherein two layers of water-permeable sheet material are disposed between said layer of contaminant-treating material and said layer of water-holding material.

Patentansprüche

1. Wasserrückhaltebereich für die Eindämmung und Behandlung von verschmutztem Wasser (18), umfassend eine wasserhaltende Erdvertiefung mit einem wasserdurchlässigen Erdboden (13); ein über dem Erdboden befindliches Schmutzstoff-Behandlungsmaterial (30), das in dem genannten Wasser befindliche Schmutzstoffe bei Kontakt behandeln kann, um die Konzentration der Schmutzstoffe in dem genannten kontaktierten Wasser zu reduzieren; eine über dem Schmutzstoff-Behandlungsmaterial befindliche Schicht aus wasserrückhaltendem Material (28) und eine zwischen dem Schmutzstoff-Behandlungsmaterial (30) und dem wasserrückhaltenden Material (28) befindliche Schicht aus wasserdurchlässigem Folienmaterial (34), wobei das genannte wasserrückhaltende Material (28) die Durchdringung von verschmutztem Wasser mit einer für die Behandlung durch das genannte Schmutzstoff-Behandlungsmaterial (30) vorbestimmten Rate zuläßt; und eine auf der Außenseite des wasserrückhaltenden Materials (28) und des Schmutzstoff-Behandlungsmaterials (30) befindliche Schicht aus wasserdurchlässigem Folienmaterial (32, 36).

2. Wasserrückhaltebereich nach Anspruch 1, wobei das Schmutzstoff-Behandlungsmaterial (30) eine strukturell stabile Schicht aus Behandlungsmaterial zwischen einer unteren und einer oberen Schicht aus wasserdurchlässigem Folienmaterial (32, 34) ist und wobei sich die Schicht aus wasserrückhaltendem Material (28) auf der oberen Schicht aus wasserdurchlässigem Folienmaterial befindet und darüber hinaus eine weitere Schicht aus wasserdurchlässigem Folienmaterial (26) auf einer Oberseite der genannten Schicht aus wasserrückhaltendem Material umfaßt.



3. Wasserrückhaltebereich nach Anspruch 2, wobei sich die Schicht aus Schmutzstoff-Behandlungsmaterial zwischen zwei Schichten aus wasserdurchlässigem Folienmaterial befindet und wobei sich die Schicht aus wasserrückhaltendem Material zwischen zwei weiteren Schichten aus wasserdurchlässigem Folienmaterial befindet. 5
4. Wasserrückhaltebereich nach Anspruch 1, 2 oder 3, wobei das Schmutzstoff-Behandlungsmaterial (30) ein Zeolith oder ein organophiler Ton ist. 10
5. Wasserrückhaltebereich nach Anspruch 4, wobei das Schmutzstoff-Behandlungsmaterial (30) ein mit einem quaternären Amin reagierter Montmorillonit-Ton ist, wobei der quaternäre Amin den Montmorillonit-Ton organische Verbindungen adsorbieren bzw. absorbieren läßt. 15 20
6. Wasserrückhaltebereich nach Anspruch 1, 2 oder 3, wobei das Schmutzstoff-Behandlungsmaterial (30) aus einer Gruppe bestehend aus einem Schmutzstoff-Adsorber, einem Schmutzstoff-Absorber, einem Schmutzstoff-Reaktanten, einem Schmutzstoff-Ionenaustauschmaterial und einem Schmutzstoff-Neutralisationsmittel ausgewählt wird. 25 30
7. Wasserrückhaltebereich nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das wasserrückhaltende Material (28) aus einem in Wasser quellbaren Ton besteht. 35
8. Wasserrückhaltebereich nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das wasserdurchlässige Folienmaterial (34) eine Gewebefolie umfaßt. 40
9. Wasserrückhaltebereich nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das wasserrückhaltende Material (28) eine Wasserdurchlässigkeit von 1×10^{-7} cm/Sek. oder weniger aufweist. 45
10. Verfahren zum Eindämmen von verschmutztem Wasser (18) in einem wasserrückhaltenden Erdbereich und zum Behandeln von Wasser, das ein in der Nähe eines Erdbodenabschnitts des Wasserrückhaltebereichs befindliches wasserrückhaltendes Material durchdringt, so daß darin enthaltene Schmutzstoffe entfernt oder neutralisiert werden, wobei über dem Erdboden des Wasserrückhaltebereichs ein mehrschichtiger gefertigter Artikel angebracht wird, umfassend eine unter einer

Schicht aus wasserrückhaltendem Material (28) befindliche Schicht aus Schmutzstoff-Behandlungsmaterial (30) und eine dazwischen gelegene Schicht aus wasserdurchlässigem Folienmaterial (34) sowie eine Schicht aus wasserdurchlässigem Folienmaterial (32, 36) auf der Außenseite des wasserrückhaltenden Materials (28) und des Schmutzstoff-Behandlungsmaterials (30), wobei das genannte Schmutzstoff-Behandlungsmaterial (30) das verschmutzte Wasser behandeln kann, das das wasserrückhaltende Material (28) durchdringt, um die Schmutzstoffkonzentration des durch das Schmutzstoff-Behandlungsmaterial (30) fließenden Wassers zu reduzieren, und wobei das genannte wasserrückhaltende Material (28) die Durchdringung von verschmutztem Wasser in einer für die Behandlung durch das genannte Schmutzstoff-Behandlungsmaterial vorbestimmten Rate zuläßt.

11. Verfahren nach Anspruch 10, umfassend die folgenden Schritte: Vorbereiten eines Schmutzstoff-Behandlungsmaterials als strukturell stabile Schicht aus Schmutzstoff-Behandlungsmaterial zwischen Gewebefolien und Vorbereiten eines wasserrückhaltenden Materials als strukturell stabile Schicht aus wasserrückhaltendem Material zwischen zwei anderen Gewebefolien, wobei das genannte wasserrückhaltende Material die Durchdringung des verschmutzten Wassers durch den Erdboden verlangsamt; Anbringen der Schicht aus Behandlungsmaterial über dem Erdboden und Anbringen der Schicht aus wasserrückhaltendem Material über der Behandlungsschicht zur Bildung des wasserrückhaltenden Erdbereichs, wobei das genannte Schmutzstoff-Behandlungsmaterial das verschmutzte Wasser behandeln kann, das das wasserrückhaltende Material durchdringt, um die Schmutzstoffkonzentration des durch das Schmutzstoff-Behandlungsmaterial fließenden Wassers zu reduzieren.

12. Verfahren nach Anspruch 10 oder 11, wobei das Schmutzstoff-Behandlungsmaterial (30) ein Zeolith oder ein organophiler Ton ist.

13. Verfahren nach Anspruch 12, wobei das Schmutzstoff-Behandlungsmaterial (30) ein mit einem quaternären Amin reagierter Montmorillonit-Ton ist, wobei der quaternäre Amin den Montmorillonit-Ton organische Verbindungen adsorbieren bzw. absorbieren läßt.

14. Verfahren nach Anspruch 10 oder 11, wobei das Schmutzstoff-Behandlungsmaterial (30) aus einer Gruppe bestehend aus einem



Schmutzstoff-Adsorber, einem Schmutzstoff-Absorber, einem Schmutzstoff-Reaktanten, einem Schmutzstoff-Ionenaustauschmaterial und einem Schmutzstoff-Neutralisationsmittel ausgewählt wird.

15. Verfahren nach einem der Ansprüche 10 bis 14, wobei das wasserrückhaltende Material (28) aus einem in Wasser quellbaren Ton besteht.

16. Verfahren nach Anspruch 14, wobei das wasserrückhaltende Material (28) eine Wasserdurchlässigkeit von 1×10^{-7} cm/Sek. oder weniger aufweist.

17. Gefertigter Artikel zur Verwendung bei der Eindämmung und Behandlung von verschmutztem Wasser, umfassend ein Schmutzstoff-Behandlungsmaterial (30), das in dem genannten Wasser befindliche Schmutzstoffe bei Kontakt behandeln kann, um die Konzentration von Schmutzstoffen in dem genannten kontaktierten Wasser zu reduzieren; eine Schicht aus wasserrückhaltendem Material (28), wobei das genannte wasserrückhaltende Material die Durchdringung von verschmutztem Wasser in einer für die Behandlung durch das genannte Schmutzstoff-Behandlungsmaterial vorbestimmten Rate zulässt; eine zwischen dem Schmutzstoff-Behandlungsmaterial und dem wasserrückhaltenden Material befindliche Schicht aus wasserdurchlässigem Folienmaterial (34); und eine auf der Außenseite des wasserrückhaltenden Materials (28) und des Schmutzstoff-Behandlungsmaterials (30) befindliche Schicht aus wasserdurchlässigem Folienmaterial (32, 26).

18. Gefertigter Artikel nach Anspruch 17, wobei sich zwischen der genannten Schicht aus Schmutzstoff-Behandlungsmaterial und der genannten Schicht aus wasserrückhaltendem Material zwei Schichten aus wasserdurchlässigem Folienmaterial befinden.

Revendications

1. Zone de retenue d'eau servant à contenir et traiter l'eau contaminée (18), comportant une cuvette en terre capable de retenir l'eau, dotée d'un fond en terre (13) perméable à l'eau; un matériau (30) de traitement du contaminant disposé au-dessus du fond en terre et capable de traiter un contaminant dans l'eau dès la mise en contact pour réduire la concentration du contaminant dans cette eau; une couche de matériau de retenue d'eau (28) disposée au-

dessus du matériau (30) de traitement du contaminant, et une couche faite de feuilles (34) perméables à l'eau disposée entre le matériau (30) de traitement du contaminant et le matériau de retenue d'eau (28), ce matériau de retenue d'eau (28) pouvant être pénétré par l'eau contaminée à un taux prédéterminé pour le traitement par le matériau (30) de traitement du contaminant; et aussi une couche faite de feuilles (32, 26) perméables à l'eau sur la surface extérieure du matériau de retenue d'eau (28) et aussi du matériau (30) de traitement du contaminant.

2. Zone de retenue d'eau selon la revendication 1, dans laquelle le matériau (30) de traitement du contaminant est préparé sous forme de couche structuralement stable de matériau de traitement entre les couches inférieure et supérieure des feuilles (32, 34) perméables à l'eau, et dans laquelle la couche de matériau de retenue d'eau (28) est disposée sur la couche supérieure des feuilles perméables à l'eau, et qui comporte en outre une autre couche de feuilles (26) perméable à l'eau sur une surface supérieure de la couche de matériau de retenue d'eau.

3. Zone de retenue d'eau selon la revendication 2, dans laquelle la couche de matériau de traitement du contaminant est disposée entre deux couches de feuilles perméables à l'eau, et dans laquelle la couche de matériau de retenue d'eau est disposée entre deux autres couches de feuilles perméables à l'eau.

4. Zone de retenue d'eau selon les revendications 1, 2 ou 3, dans laquelle le matériau (30) de traitement du contaminant est une zéolite ou une argile organophile.

5. Zone de retenue d'eau selon la revendication 4, dans laquelle le matériau (30) de traitement du contaminant est une argile montmorillonite traitée avec une amine quaternaire capable de rendre l'argile montmorillonite adsorbante ou absorbante des composés organiques.

6. Zone de retenue d'eau selon les revendications 1, 2 ou 3, dans laquelle le matériau (30) de traitement du contaminant est sélectionné dans un groupe qui comporte: un adsorbant de contaminant, un absorbant de contaminant, un réactant de contaminant, un matériau échangeur d'ions avec le contaminant, et un agent de neutralisation du contaminant.



7. Zone de retenue d'eau selon l'une quelconque des revendications précédentes, caractérisée par le fait que le matériau de retenue d'eau (28) comprend une argile qui gonfle dans l'eau. 5
8. Zone de retenue d'eau selon l'une quelconque des revendications précédentes, caractérisée par le fait que les feuilles (34) perméables à l'eau comprennent des feuilles en tissu. 10
9. Zone de retenue d'eau selon l'une quelconque des revendications précédentes, caractérisée par le fait que le matériau de retenue d'eau (28) est d'une perméabilité à l'eau égale ou inférieure à 1×10^{-7} cm/ sec. 15
10. Méthode servant à contenir l'eau contaminée (18) qui se trouve dans une zone de retenue d'eau en terre, et à traiter l'eau qui pénètre dans un matériau de retenue d'eau disposé à proximité du fond en terre de la zone de retenue d'eau, ceci pour enlever ou neutraliser un contaminant dans cette eau, et qui consiste à placer sur le fond en terre de la zone de retenue d'eau une unité multicouche fabriquée comportant une couche de matériau (30) de traitement du contaminant disposée au-dessous d'une couche de matériau de retenue d'eau (28), ces deux couches étant séparées par une couche faite de feuilles perméables à l'eau (34), et une couche faite de feuilles (32, 26) perméables à l'eau sur la surface extérieure du matériau de retenue d'eau (28) et aussi du matériau (30) de traitement du contaminant, ce matériau (30) de traitement du contaminant étant capable de traiter l'eau contaminée qui pénètre dans le matériau de retenue d'eau (28) afin de réduire la concentration du contaminant dans l'eau qui passe à travers le matériau (30) de traitement du contaminant, ce matériau de retenue d'eau (28) pouvant être pénétré par l'eau contaminée à un taux prédéterminé pour le traitement par le matériau de traitement du contaminant. 20 25 30 35 40 45
11. Méthode selon la revendication 10, comportant les étapes qui consistent à préparer un matériau de traitement du contaminant sous forme de couche structuralement stable de matériau de traitement entre les feuilles en tissu, et à préparer un matériau de retenue d'eau sous forme de couche structuralement stable de matériau de retenue d'eau entre deux autres feuilles en tissu, ce matériau de retenue d'eau étant capable de ralentir la pénétration de l'eau contaminée dans le fond en terre; à placer la couche de matériau de traitement au-dessus du fond en terre, et à placer la couche de matériau de retenue d'eau au-dessus de la couche de traitement pour former la zone de retenue d'eau en terre, ce matériau de traitement du contaminant étant capable de traiter l'eau contaminée qui pénètre dans le matériau de retenue d'eau afin de réduire la concentration du contaminant dans l'eau qui passe à travers le matériau de traitement du contaminant. 5 10 15
12. Méthode selon la revendication 10 ou 11, par laquelle le matériau (30) de traitement du contaminant est une zéolite ou une argile organophile. 15
13. Méthode selon la revendication 12, par laquelle le matériau (30) de traitement du contaminant est une argile montmorillonite traitée avec une amine quaternaire capable de rendre l'argile montmorillonite adsorbante ou absorbante des composés organiques. 20
14. Méthode selon la revendication 10 ou 11, par laquelle le matériau (30) de traitement du contaminant est sélectionné dans un groupe qui comporte: un adsorbant de contaminant, un absorbant de contaminant, un réactant de contaminant, un matériau échangeur d'ions avec le contaminant, et un agent de neutralisation du contaminant. 25 30
15. Méthode selon l'une quelconque des revendications 10 à 14, par laquelle le matériau de retenue d'eau (28) comprend une argile qui gonfle dans l'eau. 35
16. Méthode selon la revendication 4, par laquelle le matériau de retenue d'eau (28) est d'une perméabilité à l'eau égale ou inférieure à 1×10^{-7} cm/ sec. 40
17. Unité fabriquée utilisée pour contenir et traiter l'eau contaminée, comportant un matériau (30) de traitement du contaminant, ce matériau étant capable de traiter un contaminant dans l'eau dès la mise en contact pour réduire la concentration du contaminant dans cette eau; une couche de matériau de retenue d'eau (28), ce matériau de retenue d'eau pouvant être pénétré par l'eau contaminée à un taux prédéterminé pour le traitement par le matériau de traitement du contaminant; une couche faite de feuilles (34) perméables à l'eau disposées entre le matériau de traitement du contaminant et le matériau de retenue d'eau; et une couche faite de feuilles (32, 26) perméables à l'eau sur la surface extérieure du matériau de retenue 45 50 55



d'eau (28) et aussi du matériau (30) de traitement du contaminant.

18. Unité fabriquée selon la revendication 17, dans laquelle deux couches de feuilles perméables à l'eau sont disposées entre la couche de matériau de traitement du contaminant et la couche de matériau de retenue d'eau.

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