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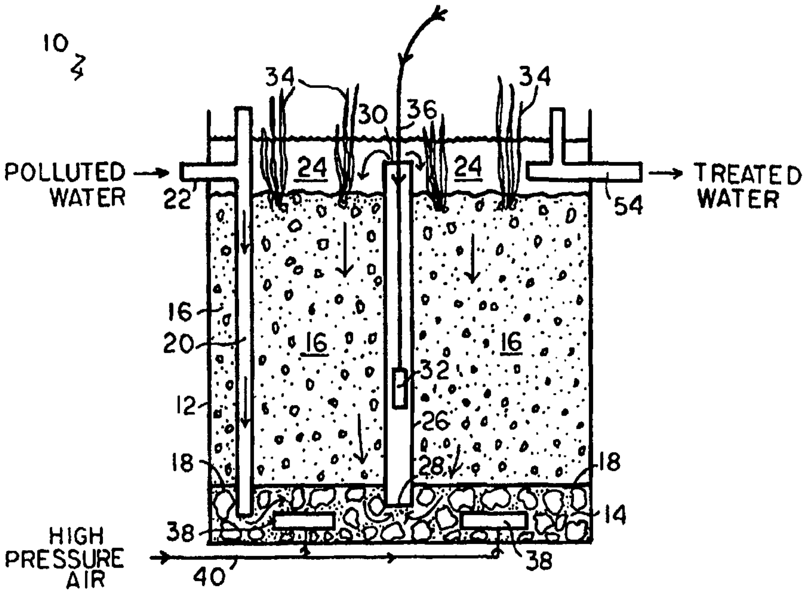

(57) Abstract

An ecological fluidized bed system and method for the processing of polluted water to provide treated water is disclosed. The system includes a fluidized bed container (12) containing a layer of coarse media (14) with a layer of fine media (16) above it which has a buoyancy substantially similar to the polluted water, and particularly pumice rock having a high surface to volume ratio, an inlet (22) to introduce water into the container, and an outlet (54) to withdraw treated water, and either a mechanical pump (46) in an anaerobic operation or an airlift pump (32) in an aerobic operation. The system includes an ecosystem such as microoganisms, benthic animals, and higher aquatic plants for the purification of polluted water within the container, and a pump to provide for the rapid recirculation of the polluted water within the container with the fine media as a fluidized bed, with a recirculation rate up to a thousand times the flow-through water rate, thereby providing for the rapid, efficient and effective purification of the polluted water.

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SYSTEM AND METHOD FOR TREATMENT OF POLLUTED WATER

Description

Background of the Invention

A wide variety of techniques and systems have been developed for the treatment and purification of polluted water, typically employing biologically active microorganisms and treating the polluted or waste water in various containers. Various forms of beds and biological filters have been used in the purification of water. One technique, for example, for removing pollutants from various types of waste water, is described in U.S. Patent No. 5,087,353 issued February 11, 1992, hereby incorporated by reference, wherein a solar aquatic apparatus is employed for treating waste water.

It is desired to provide for a new, effective and improved method for treating polluted or waste water, to reduce BOD and TSS, to provide rapid nitrification when used in an aerobic operation, to provide a high rate of denitrification when used in an anaerobic operation, to reduce levels of phosphorous, to enhance and accelerate other biological processes in the purification of the polluted or waste water such as a reduction in fats, oils, greases and to accelerate the breakdown of toxic materials using biological strategies and to reduce pathogen levels in the polluted water, to provide for a treated water.

Summary of the Invention

The invention relates to a ecological fluidized bed system and method for the treatment and processing of polluted or waste water to provide a treated or purified water. In particular, the invention concerns the employment of an ecological fluidized bed containing a semi-buoyant, but not limited to, fine particulate media and rapidly recycling or recirculating the polluted water with the semi-buoyant fine media in a water treatment ecosystem within the bed, so as to substantially increase the exposure of the polluted water to the community of the ecosystem prior to discharge of the treated water.

The invention comprises an ecological fluidized bed system for the processing of polluted water to provide treated water, which system comprises a fluidized bed container, which may either be a fixed container or a flexible plastic bag-type container. The container contains a water-porous water filter layer of a coarse particulate media in the bottom of the container, and which coarse media is typically not subject to substantial movement by water flow through the container due to its density, and optionally may contain a porous mesh or other barrier sheet material on the upper surface thereof. The container also includes a layer of, for instance, at rest, a fine particulate semi-buoyant media on or above the layer of coarse media, and which fine media material has a substantially neutral water buoyancy, for example, a specific gravity of 0.9 to 1.1, and is characterized by a high surface to volume ratio, for example, a surface area to volume ratio substantially greater than a smooth sphere. Typically the media would have a roughened type, non-smooth surface and having a variable particle size with generally a mean particle size of less than about one inch in diameter and subject to being admixed with, moved and recycled with the polluted water in the container to form a fluidized bed of the water and fine media, and, for example, may comprise, but not be limited to, porous-type pumice rock or the like.

The fine media, such as porous fine media like pumice rock, may be pre-impregnated with bacteria and nutrients and other ecosystem elements prior to admixture with the polluted water and recycling in the container.

The container also contains an inlet for the introduction of polluted water, generally into the coarse layer of the container, which polluted water substantially fills the container in operation and, for example, is introduced into the upper portion of the container and directed by a pipe to the coarse media layer. The container also includes an outlet, generally at the upper portion of the container, for the withdrawal of treated water, with the polluted water introduced and the treated water withdrawn establishing a flow-through rate of the water in the ecological fluidized bed container. The container also contains an ecosystem means to treat the polluted water introduced and to provide treated water to be discharged. For example, organic matter, mineral and micronutrient, bacteria, fungi, protozoa, nematodes, benthic animals, mollusks, snails, higher plants, microorganisms, or a combination thereof, typically to provide a complete and balanced ecosystem for the treatment of the polluted water. The system also includes a pump means, typically in an aerobic operation an airlift pump and in an anaerobic operation a mechanical pump to provide for the rapid recycling and recirculation of the polluted water together with the fine media in the presence of the ecosystem in the container. The recycled or recirculation rate within the bed or container should be at least ten times the flow-through rate and typically more than 100 and up to about one thousand times the flow-through rate to increase substantially the exposure of the polluted water to the ecosystem community within the container, therefore providing for treating polluted water, including sewerage and industrial waste water, and for the purification of natural bodies of water, and drinking water reservoirs.

The ecological fluidized bed system provides for the employment of fine media material with high surface to volume ratio, and with the media and the polluted water together within an ecosystem rapidly recycled using the dispersed, semi-buoyant fine media as a fluidized bed within a container. It is important that high surface rates of exchange may be made within the ecological fluidized bed, since the purification rates of the polluted water are dependent on available surface area and the hydraulic flows with the fine media, together with the polluted water, so that rapid recirculation, for example, up to one thousand time the flow-through rate, is incorporated as a strategy for increasing the exposure of the polluted water to the community of microorganisms and other parts of the ecosystem to the fine media, typically a balanced ecosystem to treat the water to a desired level of treatment before discharge. The method provides for a stable, high surface area micro-environment site for the microorganism and the other portions of the ecosystem. Also, rapid exchange across biological surfaces, direct ammonium and nitrate uptake, nitrification and denitrification cycles support higher plant life and root system within the media, and the aquatic environment in the ecological fluidized bed, and permits self-cleaning of the ecological fluidized bed through the introduction periodically of air or water, typically high-pressure air or water, in order to dislodge solid waste material from the coarse and fine media and to flush the material out the outlet of the bed.

The ecological fluidized bed system preferably employs a lower bottom layer of coarse media material. This is optional, however, and the bed may be operated by employing only a fine media material. The fine and coarse media material may comprise a wide variety of particulate type material. The coarse layer material should be of larger size and not be subject to movement due to the high recirculation rate within the bed. The porous lower layer, for example, should have sufficient depth to permit the introduction of the polluted water into the coarse media layer at the bottom, and thus the coarse media layer may comprise heavy rocks, sand or other coarse media, heavy particulate material.

The container has an outlet generally at or near the top of the container for the removal of treated water. Where the fine media has a specific gravity of less than about 1, i.e., tends to be buoyant, a filter mesh material may be placed across the top of the container generally below the treated water outlet, so that treated water may be removed without fine media particles dispersed therein or a separate fine media filter used in the outlet. Typically, where the fine media does not tend to remain at the top of the water in the container, e.g. where the fine media has a specific gravity generally greater than 1.0, then after operation for a period of time, a layer of generally clear treated water will accumulate at the top of the container and the clear, treated water withdrawn through the outlet for recovery, further processing or further fluidized bed treatment.

The fine media material employed typically should have a density approaching about that of the polluted water, that is to be semi-buoyant to be easily recycled along with the polluted water and the ecosystem employed within the container. One preferred example is the employment of fine pumice rock, which has a rough surface area, is somewhat porous and typically has a mean particle size of one inch or less, and generally from 1/4 to 1-1/2 inch, which has been found to have been satisfactory in certain ecological fluidized bed system operations. Sufficient of the fine media material is employed to permit the desired recycling with the polluted water and to provide the desired surface area with the selected recycle rate and recycle times. Typically, the amount of fine media material employed ranges from about 10 to 60 percent, e.g. 20 to 50 percent of the volume of the water in the container. The fine and coarse media material may vary in materials, and may include rock material as well as plastic-type materials; however, materials having a rough surface area to give a high surface area to volume ratio are most desirable to provide for a surface for the attachment of microorganisms and other ecosystem materials. Also in the preferred configuration, the total balance ecosystem is employed in the polluted water and the fine and coarse media material, which may be the same material with the fine material, naturally buoyant or almost so in order that there is small movement within the media caused by the recycling of the water, with a preferred medium comprising pumice rock and other materials with a neutral or almost neutral buoyancy.

When the ecological fluidized bed is run as an aerobic operation, an efficient method of recycling the polluted water within the bed is an airlift pump, so that diffused air in a pipe draws water from the lower or the bottom part of the container and moves through the pipe and floods the area above the coarse medium. The airlift pump aerates the water and is an efficient method of moving large volumes while employing low hydraulic heads, and the aerobic operation allows the nitrification cycle to take place within the fluidized bed in the container.

When the ecological fluidized bed system is run in an anaerobic operation, a denitrification cycle takes place. In this operation, the ecological fluidized bed is called an up-flow denitrifier system. Employment of a mechanical pump within a sump enables the polluted water to be recycled within the fluidized bed container by rising up through the media. This up-flow system permits the nitrogen gas given off as part of the denitrification cycle to be carried to the top surface of the water in the container and to be discharged to the atmosphere. The avoidance of gas pockets within the media is thus helpful in this process. In the anaerobic operation, the fluidized bed should have minimized contact with air and may also include a cover with means to reduce contact with the air and provide an outlet to discharge nitrogen.

In both systems, plants can be grown on the surface of the ecological fluidized bed, in the fine or coarse media such as higher aquatic plants, with the plant roots penetrating the media to provide helpful additional substrates, while the plants also have the ability to take up nutrients and sequester metals from the water. In addition, it is useful to employ filter feeders such as clams and snails to grow on the uppermost level of the ecological fluidized beds. A fluidized bed of the system may be employed alone or in a series of parallel or series arrangements. For example, an individual ecological fluidized bed can be contained within a separate tank, as a cell within a lagoon-type structure, and also within a flexible film container in the form of a bag or a liner, with typically the top of the bag attached to a flotation collar to permit the flotation of the ecological fluidized bed in a body of water. The flexible bag container is filled with pumice rock or media along with suitable plumbing and pumping means. The whole arrangement is then floated in the body of water.

The water may simply act as a support system for the containment bag, or may be used for the on-site treatment of natural water bodies and waste treatment lagoons whereby the ecological fluidized bed may draw water from the surrounding body of water, purify and discharge the water back into the body of water. The employment of lagoon-type structures and or bag-type ecological bed systems allows for the economic deployment of large numbers of ecological fluidized beds as separate cells in a relatively inexpensive and easily managed form for the efficient and effective treatment of polluted water. The polluted water, which may be treated by the ecological fluidized bed system, may comprise a wide variety of waste water for all different conditions including sewerage and industrial waste water.

The invention will be described for the purposes of illustration only, in connection with certain embodiments, however, it is recognized that those persons skilled in the art may make various changes, modifications, additions and improvements to the illustrative embodiments without departing from the spirit and scope of the invention.

Brief Description of the Drawings

Fig. 1 is a schematic, illustrative sectional view of an aerobic ecological fluidized bed system of the invention.

Fig. 2 is a schematic, illustrative sectional view of an anaerobic up-flowing ecological fluidized bed system of the invention.

Fig. 3 is a schematic, illustrative top plan view of an ecological fluidized bed system in a lagoon configuration.

Fig. 4 is a sectionalized view of Fig. 3 along line 4-4.

Fig. 5 is a sectionalized view of Fig. 3 along line 5-5.

Fig. 6 is a schematic, illustrative, sectional view of a floating ecological fluidized bed system.

Fig. 7 is a illustrative, schematic sectional view of another floating, ecological fluidized bed system.

Description of the Embodiments

Fig. 1 shows an aerobic ecological fluidized bed system 10 of the invention which comprises a container 12 with a layer of coarse medium 14 on the bottom of the container 12 such as a particulate porous rock-type material like pumice rock and the container 12 having therein a particulate, semi-buoyant fine medium material 16 such as finely divided 1/2 to 1-1/2 inch pumice rock above the coarse media and dispersed in the water. The container includes a porous mesh barrier 18, typically of plastic, which separates the coarse media layer 14 from the fine media material 16. The container includes a generally upright water inlet pipe 20 having an inlet 22 for the introduction of polluted water into the inlet pipe, the inlet pipe extending into the coarse media layer 14 at the bottom of the container 10. The water 24 forms a top layer in the container 10. The container 10 includes pipe 26 which also contains the aerator for the airlift pump 32 which recirculates the water within the system of container 10. The airlift pipe 26 has a flow path 28 in the coarse media layer 14 and its upper part close to the surface of the water 24. The airlift aerators 32 are connected to a supply of air 36. The airlift pump means used comprises tube 26 and the aerator 32. The airlift pump works by creating a lighter water column in the pipe 26 of **Fig. 1**. This is achieved by blowing air through pipe 36 to an aerator 32. The fine bubbles in the water column in pipe 26 reduce the specific gravity of this water in relation to the rest of the water in the EFB. This causes water in pipe 26 to rise to the top 30 and so into 24 and down through 16. The system 10 includes aquatic-type plants 34 having roots disposed in the fine media 16 and then upwardly form the surface of the water 24 as part of the ecosystem used to treat the polluted water. The container 12 also contains aeration devices 38 in the coarse media layer and a high pressure air and/or water supply in line 40 so that high pressure air may be periodically introduced into the aerator 38 to dislodge waste material from the coarse and porous layer 14 and to discharge the solid waste material from the discharge line 54.

The coarse media layer 14 can be comprised of coarse rock or plastic media which minimizes the disruption to hydraulic flow, while the fine media 16 employed in the container 12 should have a high surface to volume ratio; that is, have a non-smooth surface or typically a rough surface and can be composed of plastic or natural materials with a specific gravity close to one, allowing movement of the fine media 16 with the hydraulic flow of the water to form an ecological fluidized bed.The rapid recirculation rate within the container 12 can be achieved by a single airlift pump 32 or multiple pumps may be employed within the same body of the media. The air may be supplied, for example, through line 36 by an air blower matched to the design of the airlift pump such as to allow maximum recirculation rate for a minimum flow of air. The ecological fluidized bed is bioaugmented with a variety of bacteria, fungi, protozoas, nematodes and the like and animals to provide a complete ecosystem for the treatment of the polluted water introduced into the inlet 22 and to provide treated water removed from the outlet 54 from the top water layer 24. Optionally, the higher plants 34 can be grown on the top surface with their roots extending into the fine media 16. The roots of the higher aquatic plants 34 provide sites for bacteria and the plants can take up nutrients and metals from the polluted water.

In operation, air is introduced through pipe 36 to the airlift aerator 32 and water is drawn from the area of the coarse media layer 14, then passes up through the pipe from the bottom outlet 28 through pipe 26 through to the water 24 at the top of the container. This water 24 then passes down through the fine media 16 back to the coarse media layer 14 and so back up by the airlift pump 32 to the pipe 26 so as to cause a rapid recirculation flow-through rate within the ecological fluidized bed. As polluted water is introduced through inlet 22 to the container 12 it displaces water within the container and so the treated water or effluent is discharged from outlet 54. The ecosystem 10 as described provides for an efficient, aerobic, ecological fluidized bed system and method.

Fig. 2 is directed to an anaerobic ecological fluidized bed system 52 of the invention, comprising a high rate bioreactor which biologically denitrifies polluted water. The anaerobic system 52 includes a cylinder 42 placed on top of the coarse layer 14 and includes a perforated sump area 44 in the upper portion of the fine media 16, and which perforated sump area includes a mechanical pump 46 having an outlet which is discharged into the water column 48 formed between the interior surface of the container 12 and the outer surface of the cylinder 42 and with the system containing a fine media and water, one to about 3 inches above the water level of the water in the outside water column 48. As in Fig. 1, the ecological fluidized bed system 52 can be bioaugmented with suitable minerals, bacteria, organic compounds and other biologicals to assist in the performance as a denitrifier, and plants 34 may be grown optionally on the surface of the fine media 16. The system 52 has limited exposure to the oxygen in the atmosphere and as desired the container 12 may be closed by a cover to reduced contact with the atmosphere and to provide for the discharge of nitrogen.

In operation, the mechanical pump 46 and the sump 44 pumps polluted water draining into the sump 44 from the fine media fluidized bed 16 into the water column 48 outside of the cylinder 42, which causes the polluted water introduced into inlet 22 to pass down under the bottom rim of the cylinder 42 and to flow out through the coarse media layer 14 and into the fine media ecological fluidized bed 16, then the water as treated in the ecological fluidized bed is then rapidly recycled into the perforated sump 44 to the mechanical pump 46 for recirculation at a high rate. Because polluted water passed up through the fine media 16, nitrogen and other gases given off in the treatment are carried to the surface 50 of the fluidized bed. In the anaerobic system 52 as described the process of denitrification is anaerobic, which allows the recirculating water within the ecological fluidized bed system 52 to operate without adding oxygen to the water.

Figs. 3,4, and 5 are directed to a lagoon-type system employing a plurality of ecological fluidized beds, for example, as shown in Fig. 1. Although the ecological fluidized bed (EFB) system 10 of Fig. 1 can be employed as a single unit, preferably a number of EFBs can be connected together. The size and number of the EFBs in the system will depend on the strength of the pollutants and the degree of treated water desired. In addition, the flow rate of recirculation of the polluted water within one or more of the EFB systems can be adjusted depending on the hydraulic flow through the total system and the level of pollutants in the polluted water. When the multiple EFB systems are employed, the connections can be done by normal pipe work and plumbing to connect the inlets and outlets. As illustrated more particularly in Figs. 3, 4 and 5, multiple EFB systems may be constructed and employed within a lagoon. Fig. 3 being a top plan view showing a lagoon configuration with a plurality of EFBs joined with an airlift pump 32 for each EFB system, with the EFB systems both employed in series or parallel, showing a lagoon 62, with a barrier 64 across the lagoon to separate the EFB systems. Sectional views of the lagoon system 60 as shown along lines 4-4 and 5-5 of Fig. 3, illustrate, for example, the openings 66 between each of the connected EFB systems. Fig. 3 in particular shows a collection distribution header 70 for the collection of polluted water and directing the polluted water into the inlet of the plurality of EFB systems and a distribution header 68 for the collection and distribution of the polluted water which has been treated and the discharge of treated water form the lagoon system 60. In the lagoon system 60 there are optionally barriers 64 across the lagoon and these barriers allow for the pump flow of the polluted water as it passes through the barrier opening 66 between the EFB systems. The opening 66 may be a through passage without restriction or can be a valve which can be adjusted to provide for adjusted hydraulic flow to the polluted water between the various EFB systems. As the polluted water reaches the last cell or EFB system within the lagoon it is passed to a distribution header 68 as discharge. The ecology employed within the multiple EFB systems is similar to the single treatment described or may vary as desired. The lagoon system 60 as described and illustrated allows for an inexpensive way of utilizing a large number of the EFB systems in series and parallel to treat polluted or waste water in a lagoon.

The arrows shown in Figs. 1 through 5 are to illustrate the water flow of the polluted water within the lagoon system 60.

With reference to Figs. 6 and 7 are illustrated in Fig. 6 a floating EFB system 72 of the EFB system of Fig. 1, wherein the container comprises a flexible bag 12 and the system includes a flotation collar 76 on the upper level thereof, which floats the EFB system in a polluted body of water 74. In this type of system 72 a flotation collar supports in particular an EFB system in a body of water, whether as an aerobic or anaerobic system (see Figs. 1 and 2). A body of water 74 can act simply as a support medium for the particular one or more EFB systems in the body of water, which results in an inexpensive method of containment as there is a minimal need for a physical structure, since a flexible bag 12 with a flotation collar 76 is all that is required to support the-EFB treatment system within the body of water. The influent pipe work can be connected to a polluted body of water or to one or more EFB systems in a series or parallel. If desired, the floating EFB systems can then be connected in a floating arrangement by attached ropes. In Fig. 6 in operation, water is directed into the inlet 22. The airlift pump aerator 32 takes air from air source 36 as in the operation of Fig. 1, the treated water is recirculated and can then be discharged through discharge 54 either to another EFB system not shown or to the body of water 74.

Another flotation EFB system 80 is illustrated in Fig. 7, which includes an inlet pipe 82 containing an airlift pump aerator 84 in the inlet pipe with the air introduced through an air supply line 92 extending above the surface of the body of water 74 which air inlet pipe 82 contains a flexible plastic inlet tube 86 to draw polluted water from a body of water 74 into an inlet pipe 82 for introduction as polluted water in the inlet 90 and into the EFB aerobic bed system of Fig. 1, wherein the EFB system is floated in the body of water through the employment of collar-type floats 88.

The EFB systems are particularly useful for treating polluted water which may give off dangerous gases in treatment. The entire EFB system is then housed in a sealed container, which may be of a rigid or flexible material and the toxic gases can then be exhausted through pipes or through biological or activated carbon filters or the equivalent therein (not shown) to limit air pollution.

The EFB systems employed in a series or parallel might be employed around a floating barge which has a source of power and these clusters of EFB systems then can be anchored in rivers, canals, lakes and ponds, and in ocean or marine configurations for treating high volumes of polluted water with minimal energy. The power supply typically may be from wind generators and solar panels which charge battery banks to power electric blowers for the airlift pumps or may be conventional power supplies, and may be used to power the mechanical pumps for anaerobic configuration EFB systems. Or alternatively, wind power can be used to charge a pneumatic cylinder which stores compressed air for use in the airlift pump. The floating EFB systems can also be contained in extra-long, flexible containers, which with suitable flotation columns can treat extremely large volumes of water using media with specific gravity of close to 1 and flexible pipe work as described and illustrated in connection with Figs. 1 and 2. The flexible wall containers can also be housed in a ditch or trough.

As described and illustrated, the ecological fluidized bed systems provide for the rapid, efficient treatment of polluted water to a treated water state through the employment of a dispersion of fine media particles, typically semi-buoyant and in the presence of an ecosystem to treat the polluted water and then rapidly recycling and recirculating the fine media with the water in the ecosystem in a fluidized bed arrangement to provide very efficient exposure to the large surface area of the fine media with flow rates up to about 100 times the flow-through of the water in the bed system.

What is claimed is:

Claims

Claim 1: An ecological fluidized bed system for the processing of polluted water to provide treated water, which system comprises:

a) a fluidized bed container;

b) a water-purifying layer of coarse media in the bottom of the container, which coarse media is not subject to substantial movement by water flow through the container;

c) fine particulate media for mixing with the polluted water in the container on top of the layer of coarse media, which fine media has a substantially neutral water buoyancy and has a high surface area to volume ratio;

d) an inlet for the introduction of polluted water into the coarse layer of the container, the polluted water to be treated to fill substantially the container;

e) an outlet in the upper portion of the container for the withdrawal of treated water; the water introduced and withdrawn establishing a flow-through rate for water passing from the inlet to the outlet of the container;

f) an ecosystem means in the container to treat the polluted water introduced at the inlet and to provide treated water to be discharged from the outlet; and

g) a pump means to provide for the rapid recirculation of the polluted water with the fine media and ecosystem means within the container at a recirculation rate of at least ten times the flow-through rate, thereby providing for the rapid and effective purification of the polluted water.

Claim 2. The system of claim 1 which includes a mesh barrier separating means dispersed between the coarse and fine media layers.

Claim 3. The system of claim 1 which includes means to introduce periodically high pressure air into the coarse media layer to displace and carry solid waste material to the outlet.

Claim 4. The system of claim 1 wherein the fluidized bed container comprises a plastic bag container.

Claim 5. The system of claim 1 wherein the container includes a flotation collar means for flotation of the container in a body of water.

Claim 6. The system of claim 1 wherein the fine media comprises pumice rock particles having a mean particle size of less than about 1-1/2 inches.

Claim 7. The system of claim 1 wherein the coarse media comprises coarse rock or plastic media.

Claim 8. The system of claim 1 which includes as a part of the ecosystem means higher aquatic plant vegetation on the upper surface of the polluted water in the container.

Claim 9. The system of claim 1 wherein the ecosystem means is selected from the group consisting of organic matter, vegetation, mineral and micronutrient sources, microorganisms, bacteria, fungi, protozoas, nematodes, benthic animals, mollusks, snails, and combinations thereof.

Claim 10. The system of claim 1 which operates on an aerobic system and includes:

a) an airlift pipe means in the container to introduce air from an aerator means from the top of the container into the airlift pipe; and

b) the pump means comprises an airlift pump to aerate and recirculate the polluted water in the container.

Claim 11. The system of claim 1 which operates as an anaerobic system and includes:

a) a cylinder within the container on top of the coarse layer to contain the fine media and to provide an outside water column between the cylinder and the container, for the recirculation of polluted water; and

b) the pump means within the cylinder and comprising a mechanical pump in a sump and having a pump inlet within the cylinder to pump water into the water column outside of the cylinder and to recirculate the water through the water column, through the coarse media layer and through the fluidized bed of the fine media within the cylinder.

Claim 12. The system of claim 1 wherein the pump means provides for the recirculation of the polluted water, and fine media at a rate of about 10 to 1000 times the flow-through rate.

Claim 13. The system of claim 1 wherein the fine media is porous and has been pre-impregnated with selected bacteria and nutrients prior to introduction into the container.

Claim 14. A lagoon system for the purification of polluted water and the discharge of treated water, which systems comprises:

a) a lagoon;

b) a plurality of ecological fluidized bed systems of claim 1 within the lagoon;

c) a distribution header means to introduce polluted water into the plurality of said systems in the lagoon;

d) a plurality of barrier means across the lagoon to separate a plurality of aligned EFBs in separate sections;

e) means to connect the outlet of the said systems across the separated sections; and

f) distribution header means to collect and distribute treated water from the plurality of the said systems in each section of the lagoon.

Claim 15. A floating layered ecological fluidized bed system which comprises:

a) a body of water;

b) an ecological fluidized bed system of claim 1; and

c) a flotation collar means on the said bed system to permit surface flotation of the bed system in the body of water.

Claim 16. The system of claim 15 which includes outside means in the body of water to withdraw polluted water from the body of water for introduction into and treatment by the said bed system.

Claim 17. A method for the purification of polluted water to provide purified water, which method comprises:

a) providing an ecological fluidized bed comprising a container having fine porous media material with a specific gravity substantially about 0.9 to 1.0 and an inlet for the introduction of polluted water and an outlet for the withdrawal of treated water and an ecological system to convert the polluted water in the container to treated water;

b) introducing polluted water into the inlet to fill substantially this container with polluted water for admixing with the fine media;

c) recirculating the polluted water at a high flow rate with the fine media material with a flow rate sufficient to recirculate the polluted water with the fine media dispersed therein in the container in contact with the ecological system as a fluidized bed for a time to purify the polluted water and at a flow rate of up to one thousand times the flow-through rate of the water into and from the container; and

d) withdrawing treated water from the outlet of the container.

Claim 18. The method of claim 17 which includes recirculating the polluted water and dispersed media at a flow rate of about 10 to 1000 times the flow-through rate of the water introduced and withdrawn from the container.

Claim 19. The method of claim 17 which includes employing pumice stone particulate material for the fine media material.

Claim 20. The method of claim 17 which includes introducing air into the flow of the polluted water and fine media material to provide an aerobic operation.

Claim 21. The method of claim 17 which includes forming and maintaining a layer of treated water as a top layer in the container for withdrawal.

Claim 22. The method of claim 17 which includes floating the container in a body of water to be treated.

Claim 23. The method of claim 17 which includes connecting a plurality of containers together within the lagoon to provide for the introduction of a plurality of polluted water streams into a plurality of containers and the withdrawal and collection of a plurality of treated water streams.

Claim 24. The method of claim 17 which includes having higher aquatic plants located on the top of the container as part of the ecological system.

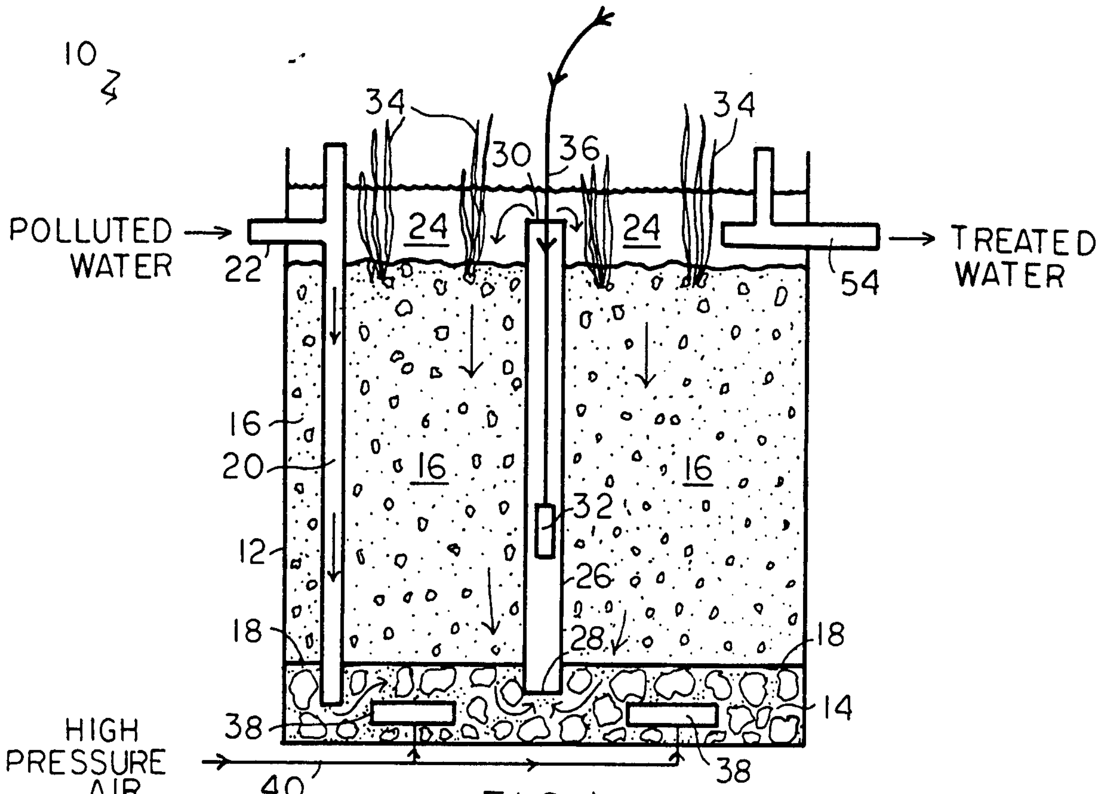
Claim 25. The method of claim 17 which includes excluding air from the container and recirculating the polluted water and the fine media material by a mechanical pump by upward flow of the polluted water and fine media material within the container to operate an anaerobic method of preparation.

Claim 26. The method of claim 17 which includes periodically introducing high pressure air into the container to dislodge and remove solid waste material.

Claim 27. The method of claim 17 which includes employing as the container a plastic bag, and floating the plastic bag in a body of water.

Claim 28. The method of claim 17 which includes employing a water porous, coarse particulate media layer on the bottom of the container and introducing and recirculating the polluted water through the coarse media layer.

Claim 29. The system produced by the method of claim 17.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TREATED WATER
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26
18
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HIGH PRESSURE AIR
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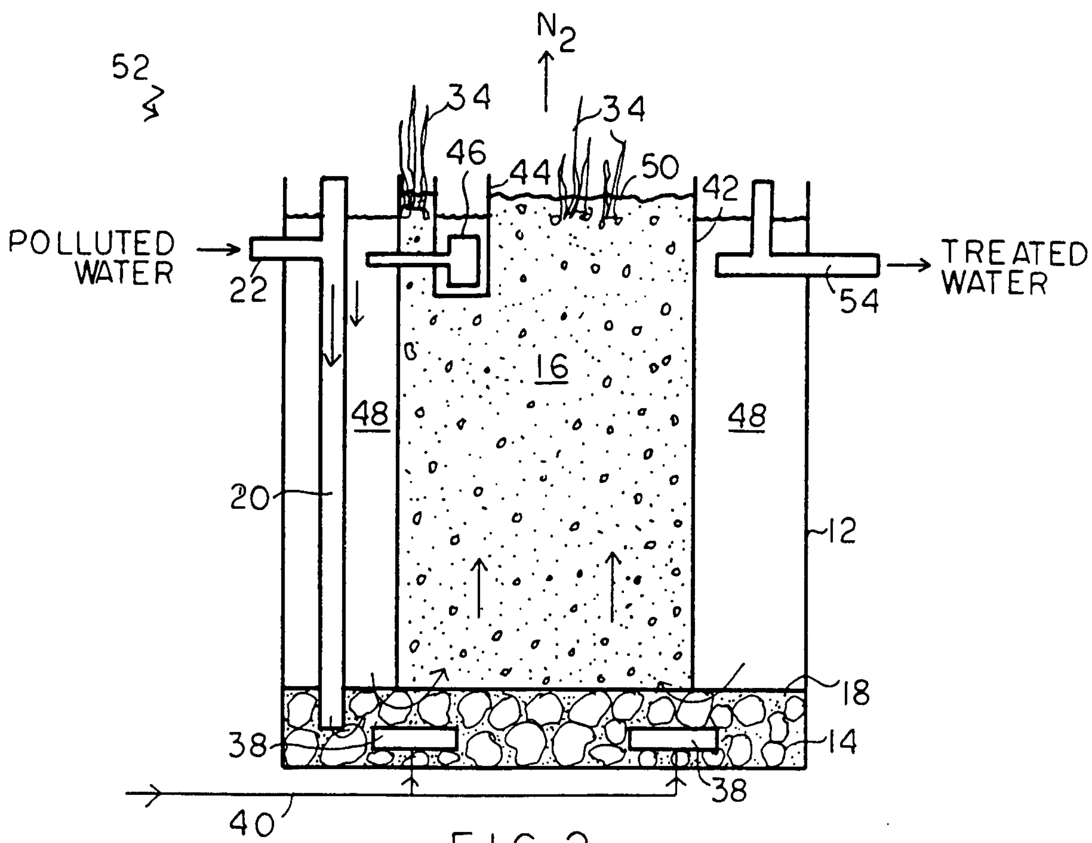
FIG. 1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N_2
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TREATED WATER
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FIG. 2

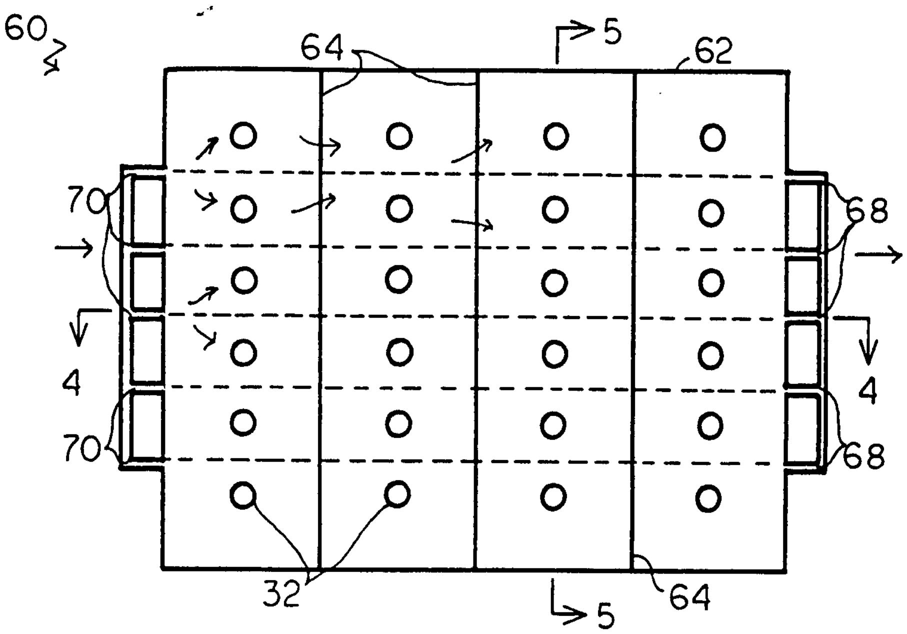

FIG.3

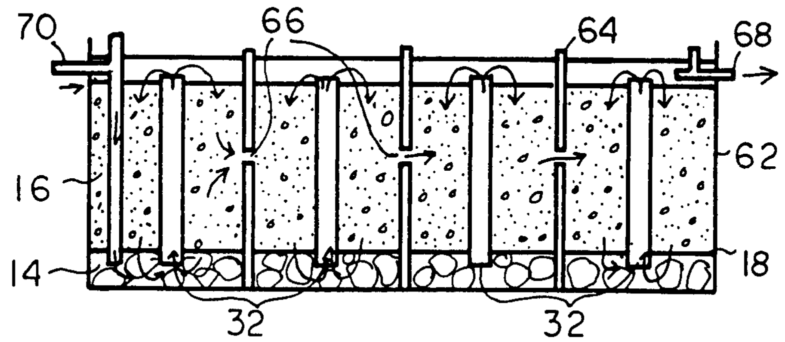

FIG.4

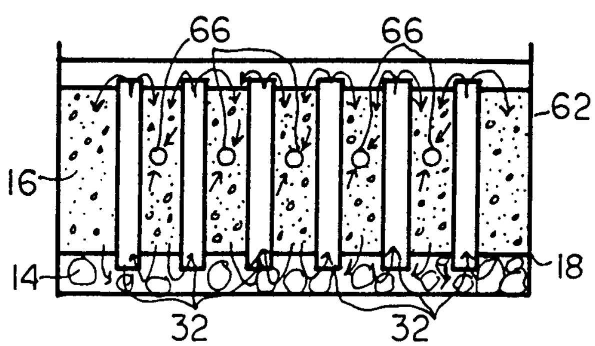

FIG.5

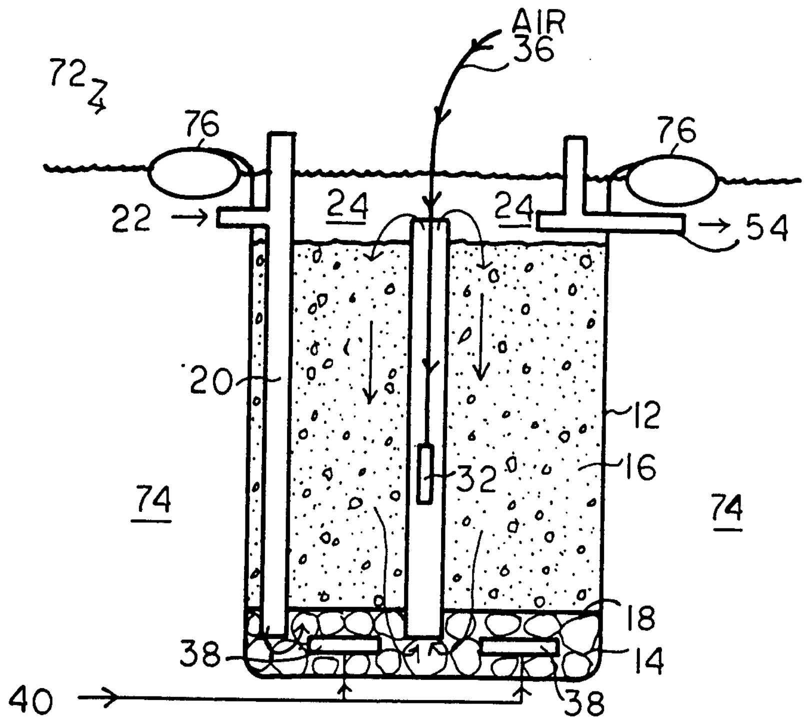

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FIG. 6

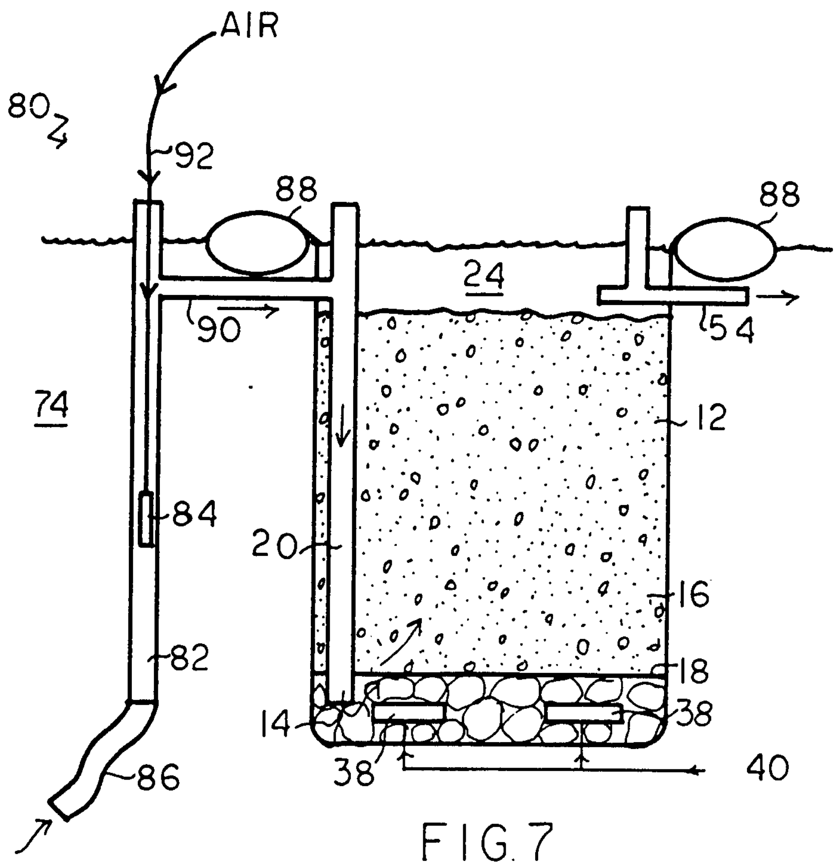

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FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/12901

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :C02F 3/08, 3/28
US CL : 210/151, 242.2, 283, 617, 629
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 210/150, 151, 170, 221.2, 242.1, 242.2, 266, 283, 290, 617, 618, 629, 747

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 3,563,888 (KLOCK) 16 February 1971, entire document.	1-10, 12-24 and 26-29
Y	US, A, 4,415,450 (WOLVERTON) 15 November 1983, Fig. 2.	1-13, 24 and 28
Y	US, A, 4,482,458 (ROVEL ET AL) 13 November 1984, entire document.	1, 2, 4-9, 11-19, 21-25 and 27-29
Y	US, A, 5,228,998 (DICLEMENTE ET AL) 20 July 1993, entire document.	5, 14-16, 22 and 27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 DECEMBER 1994	JAN 23 1995

Name and mailing address of the ISA/US	Authorized officer
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