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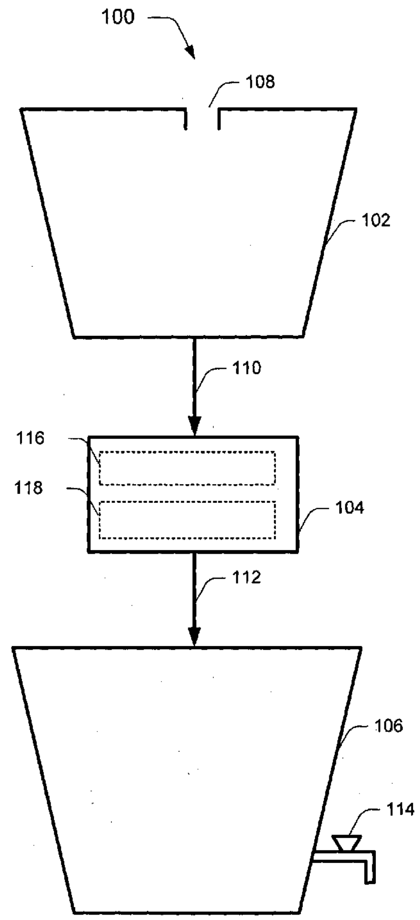
[Continued on next page]

(54) Title: DEVICE FOR WATER PURIFICATION



(57) Abstract: The subject matter described herein relates to a water purification device (104) for purification of water. The water purification device (104) includes a primary disinfectant unit (116) and a secondary disinfectant unit (118). The primary disinfectant unit (116) includes at least one silver treated porous media (302) configured to inactivate a first portion of microbial contaminants present in the water. Further, a second portion of the microbial contaminants present in the water is inactivated by the secondary disinfectant unit (118) having at least one halogen releasing component (402).

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TECHNICAL FIELD

DEVICE FOR WATER PURIFICATION

[0001] The present subject matter, in general, relates to a device for water purification and, in particular, to a device for removal of microbiological and particulate contaminants in water.

BACKGROUND

[0002] Generally, water available from natural sources, such as groundwater sources, or surface water sources, contains various contaminants, such as microbes like pathogenic bacteria, protozoan cysts; particulate matter; soluble salts; and heavy metals like barium, cadmium, chromium, lead, etc. Presence of excess contaminants in water makes the water unsuitable for human consumption as consumption of contaminated water may cause various waterborne diseases. Thus, various purification techniques have been developed conventionally to remove the contaminants.

[0003] Typically, contaminated water is treated at source, such as at municipal water treatment plants. Water from the source is distributed to various users for consumption. However, even after treatment at the source, contamination may occur during distribution. Therefore, to curb spread of waterborne diseases, various water purification devices are usually implemented at the point-of-use (POU) from where water can be directly consumed. The water purification devices based on technologies, such as reverse osmosis, membrane filtration, and ultra violet (UV) radiation, usually need electricity and may also require elevated water pressure for operation, thus increasing the cost of the water purification devices and limiting the use of water purification devices.

[0004] In order to facilitate use of water purification devices, various low cost water purification devices, such as ceramic filters, activated carbon filters, and filters using chemical disinfection have been developed. However, these low cost water purification devices often use a single or sometimes even no disinfectant and are thus not capable of providing adequate purification. Additionally, the treatment of contaminated water may involve inactivating the microbiological contaminants by using high concentrations of disinfectants, which imparts pungency and objectionable taste to the treated water. Thus, additional steps are introduced during the purification process to remove the excess disinfectants before delivering it for consumption which adds to the size and cost of the purifier. Further, such water purification devices are often bulky and suffer from limitations, such as clogging and poor inactivation of microorganisms like bacteria, viruses, protozoan cysts, etc.

SUMMARY

[0005] This summary is provided to introduce concepts related to water purification. These concepts are further described below in the detailed description. This summary is neither intended to identify essential features of the claimed subject matter nor is it intended for use in determining or limiting the scope of the claimed subject matter.

[0006] In one embodiment, a water purification device for purification of water is described. The water purification device includes a primary disinfectant unit, and a secondary disinfectant unit. The primary disinfectant unit includes silver treated porous media to inactivate a first portion of microbial contaminants present in the water. Further, a second portion of the microbial contaminants present in the water is inactivated by the secondary disinfectant unit having at least one halogen releasing component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The detailed description is provided with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the drawings to reference like features and components.

[0008] **Fig. 1** illustrates an apparatus for water purification, according to an embodiment of the present subject matter.

[0009] **Fig. 2(a)** illustrates a water purification device of the apparatus, according to one embodiment of the present subject matter.

[0010] **Fig. 2(b)** illustrates a water purification device of the apparatus, according to another embodiment of the present subject matter.

[0011] **Fig 3(a)** illustrates a primary disinfectant unit of the water purification device, according to an embodiment of the present subject matter.

[0012] **Fig. 3(b)** illustrates a primary disinfectant unit of the water purification device, according to another embodiment of the present subject matter.

[0013] **Fig. 4** illustrates a secondary disinfectant unit of the water purification device according to an embodiment of the present subject matter.

[0014] **Fig. 5** illustrates a graph depicting performance of the water purification device with concentration of residual disinfectants in purified water, according to an embodiment of the present subject matter.

DETAILED DESCRIPTION

[0015] The present subject matter relates to purification of water. The purification of water involves removing microbiological and physical particulate contaminants to make the water usable for various purposes, including human consumption.

[0016] Generally, consumption of contaminated water leads to spread of waterborne diseases. The spread of these diseases is likely to occur where water, used for consumption, gets contaminated by microorganisms, such as bacteria, viruses, and protozoan cysts. To curb the spread of such diseases, contaminated water is treated at source, such as at municipal water treatment plants. Water from the source is distributed to various users for consumption. However, even after treatment at the source, contamination may occur during distribution. Other methods of water purification involve treating water by certain disinfectants, filtering, or combination thereof at point-of-use (POU) from where water can be directly consumed.

[0017] Various methods of water purification used at the POU typically involve using water purification devices based on low cost technologies, such as ceramic filters, carbonaceous filtering media coated with metal disinfectants, and halogen based disinfectants. Using such low cost water purification devices at the POU helps in reducing diarrhea and other waterborne diseases caused due to pathogenic bacteria, viruses, and protozoan cysts present in contaminated water. However, these low cost water purification devices suffer from various limitations. For example, water filtered through ceramic filters suffers from inadequate removal of microbiological contaminants. Further, high concentration of halogen based disinfectants may impart unacceptable taste and odor to water. In order to remove excess disinfectants before delivering the water for consumption, additional steps are introduced during water purification process. Such additional steps add to the cost and increase the size of the water purification devices.

[0018] A device and a method for purification of water are described herein. The device employs a trace amount of silver and a halogen, wherein the synergistic action of these two disinfectants results in enhanced inactivation of microorganisms in lesser time without altering the aesthetic aspects of the water. According to an embodiment of the present subject matter, an apparatus for water purification includes a water purification device with a water inlet and a water outlet. The water inlet is used for receiving water, which may or may not have undergone prior treatment and is hereinafter referred to as untreated water, from one or more water sources. In one implementation, the water inlet may be connected to a reservoir of water. The untreated water is subsequently received by the water purification device for treatment. Purified water exits from the water purification device through the water outlet. In one embodiment, the water purification device has two stages of water purification.

[0019] A first stage of purification includes treating untreated water with a silver treated porous media. In one implementation, the silver treated porous media may be formed by treating layers of a porous media, such as rice husk ash (RHA) with silver. As the untreated water passes through the silver treated porous media, the microbial contaminants present in the untreated water are inactivated by the silver. The untreated water is thus disinfected to provide disinfected water.

[0020] The disinfected water is then purified at a second stage of purification. Here, any micro-organism, resistant to the disinfection action of the first stage of purification, gets inactivated due to presence of a different kind of disinfectant. In one implementation, the second stage of purification includes purifying the disinfected water using a halogen releasing component to release a halogen such as chlorine, iodine, and bromine. In one embodiment, the halogen used in the second stage of purification is chlorine and the halogen releasing component is provided in the form of a tablet. When the disinfected water received from the first stage of purification comes in contact with the tablet, a predetermined concentration of chlorine is released into the flowing water by the tablet. The microorganisms that were not inactivated in the first stage are thus inactivated at the second stage of purification to provide purified water. In one embodiment, the predetermined concentration of chlorine is kept in the range of about 0.1 ppm to 0.5 ppm, which is acceptable for human consumption. Maintaining a low concentration of the halogen results in elimination of the additional step of removing excess halogen from the purified water, thus decreasing the size of the water purification device and in turn, the apparatus.

[0021] The water purification device described herein inactivates microorganisms present in the untreated water, requires nominal maintenance, has high efficiency, and low operating costs. The water purification device purifies the untreated water by inactivating microorganisms in the untreated water due to a synergistic action of two different disinfectants. Further, residual concentrations of the two different disinfectants, present in the purified water, also inhibit growth of microorganisms due to any post purification contamination of water. Further, the water purification device is compact, efficient and requires no external source of energy for operation. The water purification device is suitable for use in a domestic setting or at a household level. These and other aspects are discussed in detail in conjunction with the following figures.

[0022] In one embodiment, the order of stages of purification may be implemented in any order for purification of untreated water. For example, first stage and second stage of purification may be placed interchangeably with respect to the untreated water coming through the water inlet.

[0023] Fig. 1 illustrates an apparatus 100 for water purification, according to an embodiment of the present subject matter. In said embodiment, the apparatus 100 includes a source reservoir 102, a water purification device 104, and a collection reservoir 106. The source reservoir 102 is provided for storing water, which may or may not have undergone prior treatment and is hereinafter referred to as untreated water, received from one or more water sources. The water purification device 104 purifies the untreated water to provide purified water which is subsequently received by the collection reservoir 106. In one implementation, the water purification device 104 may be connected to the source reservoir 102 in a leak proof manner.

[0024] Untreated water from a suitable source like a municipal water supply source, a well, a bore-well, a river, or any other source of drinking water may be poured into the source reservoir 102 through a water inlet 108. The untreated water from the source reservoir 102 then enters the water purification device 104 as shown by an arrow 110. In one embodiment, the untreated water may be allowed to enter the water purification device 104 at a predetermined rate. The purified water from the water purification device 104 may then flow out as shown by an arrow 112 and get collected in the collection reservoir 106. In an embodiment, the collection reservoir 106 is provided with a water outlet such as a tap 114 from which the purified water may be drawn for consumption.

[0025] In one embodiment, the water purification device 104 of apparatus 100 implements two stages of water purification. At a first stage and a second stage, the untreated water is treated with different disinfectants to inactivate microbial contaminants such as microbes like pathogenic bacteria, viruses, and protozoan cysts. In order to carry out water purification in two stages, the water purification device 104 includes a primary disinfectant unit 116 to inactivate a first portion of microbial contaminants present in the untreated water, and a secondary disinfectant unit 118 to inactivate a second portion of the microbial contaminants present in the untreated water. Although the terms primary and secondary have been used to identify the purification units related to two stages of purification, it will be understood that these terms are used merely for the purpose of reference and not as descriptive of function or importance of the two stages of purification.

[0026] In one implementation, the primary disinfectant unit 116 includes at least one silver treated porous media (not shown in this figure) for removing microbial contaminants from the untreated water. In one embodiment, the silver treated porous media may be formed by treating a porous media, such as RHA, activated carbon, clay, sand, foam, woven/nonwoven cloth, resin or combinations thereof, with a disinfectant, such as silver salt, nano particles of silver, silver oxide, and silver hydroxide. As the untreated water passes through the silver treated porous media, a first portion of the microbial contaminants present in the untreated water is inactivated by the disinfectants to provide disinfected water. The silver treated porous media is prepared such that a predetermined amount of the disinfectant is released in the untreated water, thus controlling the concentration of the disinfectant below a permissible level.

[0027] The secondary disinfectant unit 118 includes at least one halogen releasing component (not shown in this figure) to inactivate a second portion of the microbial contaminants. The halogen releasing component may include one or more halogens, such as chlorine, bromine, iodine, etc. When the disinfected water received from the primary disinfectant unit 116 at the first stage passes through the secondary disinfectant unit 118, the microorganisms that were not treated by the primary disinfectant unit 116 are inactivated by the halogen releasing component to receive purified water. Further, the halogen releasing component dissolves slowly to release the halogen into the water, such that a predetermined concentration of the halogen is maintained in the flowing water. In order to control the concentration of the halogen, the halogen releasing component may be formulated in such a way as to have predetermined dissolution rate. In one embodiment, chlorine is used as the halogen and the concentration of the chlorine is in the range of about 0.1 ppm to 0.5 ppm, which is acceptable for human consumption. Maintaining a low concentration of the halogen results in elimination of the additional step of removing excess halogen from the purified water, thus decreasing the size of the water purification device 104 and in turn of the apparatus 100.

[0028] Using the synergistic action of two disinfectants at low concentrations facilitates inactivation of pathogens in the untreated water to bring it down to required levels within a shorter period of time, as compared to conventional systems. The water purification device 104 thus demonstrates high efficiency in inactivation of microbial contaminants, good performance in treating water from various sources, and long lasting residual disinfection effect. Further, the water purification device 104 does not require the additional step of removing residual disinfectants, i.e., disinfectants present in water after purification, thus decreasing the size of the water purification device 104 and in turn of the apparatus 100.

[0029] Further, the stages of purification may be implemented in any order for purification of untreated water. For example, the first stage and the second stage of purification may be interchanged with respect to the untreated water coming through the source reservoir 102. For instance, in order to interchange the first stage and the second stage, the position of the primary disinfectant unit 116 and the secondary disinfectant unit 118 may be interchanged in the water purification device 104.

[0030] Additionally, it will be understood that although the water purification device 104 has been shown to function as a part of the apparatus 100 for purposes of discussion, the water purification device 104 may be separately connected to any reservoir or tap for purification of water.

[0031] Fig. 2(a) illustrates the water purification device 104 according to one embodiment of the present subject matter. As previously described, the water purification device

104 includes the primary disinfectant unit 116 and the secondary disinfectant unit 118. In said embodiment, the purification stages are placed such that the untreated water received from the source reservoir 102 is disinfected at the primary disinfectant unit 116 to provide the disinfected water to the secondary disinfectant unit 118. The primary disinfectant unit 116 is provided with a first inlet 202 for receiving untreated water from the source reservoir 102 and a first outlet 204 for providing disinfected water to the secondary disinfectant unit 118. The first outlet 204 is in turn connected to a second inlet 206 of the secondary disinfectant unit 118 for further purifying the disinfected water. The secondary disinfectant unit 118 then provides the purified water to the collection reservoir 106 through a second outlet 208.

[0032] Fig. 2(b) illustrates the water purification device 104 according to another embodiment of the present subject matter. In said embodiment, the secondary disinfectant unit 118 is used as the first stage of purification and the primary disinfectant unit 116 is used as the second stage of purification. In order to implement said embodiment, the second inlet 206 of the secondary disinfectant unit 118 is connected to the source reservoir 102 to receive the untreated water for disinfecting. Further, the second outlet 208 of the secondary disinfectant unit 118 is connected to the first inlet 202 of the primary disinfectant unit 116 for providing the disinfected water. The primary disinfectant unit 116 then provides the purified water to the collection reservoir 106 through the first outlet 204. The collection reservoir 106 stores the purified water which may be drawn through the tap 114 for consumption.

[0033] The purification stages of the water purification device 104 may thus be implemented in any order for treatment of untreated water. However, for the sake of clarity and not as a limitation, working of the water purification device 104 of the apparatus 100 has been described in accordance with the embodiment described in fig. 2(a).

[0034] Fig 3(a) and Fig 3(b) illustrate the primary disinfectant unit 116 of the purification device 104, according to an embodiment of the present subject matter. As previously described the primary disinfectant unit 116, in one embodiment, may be used as the first stage of purification for treating the untreated water. In another embodiment, the primary disinfectant unit 116 may be used as the second stage of purification for treating the disinfected water. However, for the sake of clarity and not as a limitation, working of the primary disinfectant unit 116 has been described as would be in the first stage of purification in accordance with the embodiment described in fig. 2(a).

[0035] The primary disinfectant unit 116 includes the first inlet 202 for receiving the untreated water, the first outlet 204 for providing the disinfected water, and silver treated porous media 302 for inactivating microbial contaminants. In one implementation, the silver treated porous media 302 may be formed by treating a porous media with a disinfectant, such as silver or nano particles of silver. Examples of porous media include, but are not limited to, rice husk ash (RHA), clay, sand, foam, woven/nonwoven cloth, resin, activated carbon, charcoal powder, saw dust, ceramics, cellular plastics, zeolites, silicates, organosilicas, silicon, alumina, aluminosilicates, metals, metal foams, metal oxides, clay minerals, carbons and carbon nanotubes, synthetic and natural organic polymers, cloth fabrics, fiber, and combinations thereof.

[0036] In one implementation, the porous media is RHA and in order to obtain the silver treated porous media 302, the RHA is exposed to silver. For example, the silver treated porous media 302 may be obtained by passing a silver solution through a bed of RHA, soaking the RHA in the silver solution, spraying the silver solution on the RHA, painting the silver on the RHA, and in-situ synthesis of nano silver within the RHA.

[0037] Further, the silver treated porous media 302 can be formed in various shapes and sizes by addition of a binder a binder, such as polyvinyl alcohol, epoxy resin, gum, maltodextrin, lactose, polyethylene, polypropylene, polyolefin, cellulose ethers, bentonite, and polyvinylpyrrolidone (PVP) such as PVP K-30 is used to form a given structure.

[0038] In one embodiment, the primary disinfectant unit 116 as illustrated in fig. 3(a) includes a purification chamber 304 having the silver treated porous media 302. In operation, as the untreated water is passed through the primary disinfectant unit 116, the untreated water enters through the first inlet 202. The untreated water flows downwards through passages 306-1 and 306-2 and enters into the purification chamber 304 from a base of the purification chamber 304 as indicated by arrows 308-1, 308-2, 308-3, 308-4, 308-5, and 308-6. The untreated water thus flows through the silver treated porous media 302 in an upward direction. Providing such a flow of the untreated water through the silver treated porous media 302 in a direction against the force of gravity helps in achieving better purification. Additionally, such a flow allows a longer and uniform period of contact between the untreated water and a purification bed of the silver treated porous media 302. Further, such a reverse flow of the untreated water also prevents formations of channels within the silver treated porous media 302 and consequently provides a more uniform purification throughout the life of the water purification device 104.

[0039] As the untreated water passes through the silver treated porous media 302, the disinfectants incorporated in the silver treated porous media 302 inactivate microbial contaminates present in the untreated water. Further, a predetermined amount of silver incorporated in the silver treated porous media 302 may leach out into the untreated water. Controlling the amount of disinfectant helps in maintaining the level of residual disinfectant in the purified water under permissible limits required for drinking water. In one implementation, the amount of residual disinfectant, say, the silver is less than 100 parts per billion (ppb). The disinfected water thus received flows through an outlet passage 310 and exits the primary disinfectant unit 116 via the first outlet 204 as indicated by arrows 312, 314, and 316.

[0040] The primary disinfectant unit 116 as illustrated in fig. 3(b) includes a purification chamber 318 having the silver treated porous media 302. In operation, as the untreated water is passed through the primary disinfectant unit 116, the untreated water enters through the first inlet 202. The untreated water flows downwards through the purification chamber 318 as indicated by an arrow 320 and comes in contact with the silver treated porous media 302. As the untreated water passes through the silver treated porous media 302, the silver incorporated in the silver treated porous media 302 inactivates the microbial contaminants present in the untreated water. The disinfected water thus received exits the primary disinfectant unit 116 via the first outlet 204 as indicated by an arrow 322.

[0041] Further, as the untreated water passes through the silver treated porous media 302 as shown in figures 3(a) and 3(b) a predetermined amount of silver is leached out into the untreated water. Controlling the amount of silver helps in maintaining the level of residual silver in the purified water under permissible limits required for drinking water. In one implementation, the amount of residual silver is less than 100 ppb. The primary disinfectant unit 116 thus inactivates a first portion of microbial contaminants present in the untreated water, using the silver treated porous media 302. Further, maintaining the amount of residual silver at a concentration of less than 100 ppb prevents post purification microbial contamination of water.

[0042] Fig. 4 illustrates components of the secondary disinfectant unit 118, according to an embodiment of the present subject matter. As previously described the secondary disinfectant unit 118, in one embodiment, may be used as the first stage of purification for treating the untreated water and in another embodiment may be used as the second stage of purification for treating the disinfected water. However, for the sake of clarity and not as a limitation, working of the secondary disinfectant unit 118 has been described to perform the second stage of purification in accordance with the embodiment described in fig. 2(a).

[0043] The secondary disinfectant unit 118 includes the second inlet 206 for receiving the disinfected water, the second outlet 208 for providing the purified water, a halogen releasing component 402 for inactivating the microbial contaminants, a plunger 404 having a plug 406 in contact with a top surface of the halogen releasing component 402 to hold the halogen releasing component 402 firmly over a base 408. The plunger 404 is supported by a spring 410 placed near the top surface of the secondary disinfectant unit 118. Further, the halogen releasing component 402, the plunger 404, and the spring 410 are enclosed in a casing 412 attached to the base 408.

[0044] The base 408 includes one or more supports 414-1 and 414-2, hereinafter collectively referred to as support(s) 414, to rest the halogen releasing component 402, an inlet passage 416 for transporting the disinfected water received from the second inlet 206 to a central opening 418, radial channels (not shown in the figure) for the passage of water, as indicated by arrows 420-1, 420-2, and to control the dissolution of the halogen releasing component 402, and one or more outlet passages 422-1 and 422-2, hereinafter collectively referred to as outlet passage(s) 422 to carry the purified water from the radial channels to the second outlet 208.

[0045] In one implementation, the secondary disinfectant unit 118 is configured to release halogens, from a composition, such as the halogen releasing component 402 provided in the form of a tablet, at a predetermined rate in to the water flowing through it.

[0046] The halogen releasing component 402 includes at least one halogen which acts as a disinfectant for inactivating the microbial contaminants that were not removed by the primary disinfectant unit 116 and are thus still present in the disinfected water. Examples of the halogens include, but are not limited to, chlorine, iodine, and bromine. In one embodiment, the halogen may be chlorine. In another embodiment, the halogen may be chlorine in the form of chlorine releasing compounds, such as calcium hypochlorite, sodium hypochlorite, sodium dichloroisocyanurate, chloramines-T, chlorinated tri sodium phosphate, lithium hypochlorite, trichloroisocyanuric acid, and combinations thereof.

[0047] Further, the halogen releasing component 402 may be dosed in the form of liquid, solid or gas. In one embodiment, the halogen releasing component 402 is proved in the form of a tablet of any shape including but not limited to cubical, cylindrical, disc, and prism shape. The tablet may be composed of a combination of the halogen releasing component 402, additives, lubricants, and binders. The additives, in one example, may include calcium sulphate, magnesium sulphate, calcium carbonate, magnesium carbonate, sodium persulphate, potassium phosphate, dibasic calcium phosphate, aluminium sulphate, ferric sulphate, aluminium hydroxide, ferric hydroxide, adipic acid, boric acid, cyanuric acid, cellulose, starch, glucose, lactose, mannitol, sorbitol, and combinations thereof. Further, the additives may be added in the range of about 0 % to 90 % by weight.

[0048] Examples of the binders include, but are not limited to, sucrose, lactose, starch, cellulose, microcrystalline cellulose, hydroxypropyl cellulose, sorbitol, mannitol, gelatin, polyvinylpyrrolidone (PVP), PVP K-30, polyethylene glycol (PEG), and combinations thereof. Further, the binders may be added in the range of about 0 % to 60 % by weight. For example, polyvinylpyrrolidone (PVP), such as PVP-K 30, may be added in the range of in the range of about 0 % to 60 % by weight.

[0049] The lubricants, in one example, may include talc, silica, sodium stearate, magnesium stearate, stearic acid and combinations of thereof. Further, the lubricants may be added in the range of about 0 % to 60 % by weight.

[0050] In accordance with an embodiment of the present subject matter, the halogen releasing component 402 is composed of a chlorine releasing compound such as calcium hypochlorite, sodium dichloroisocyanurate, and trichloroisocyanuric acid in the range of about 5 % to 100 % by weight, an additive such as calcium sulphate, as a diluent to slow down the tablet dissolution rate, in the range of 0% to 90% by weight, PVP K-30 in the range of about 0 % - 60 % by weight to function as a binder, and magnesium stearate in the range of about 0 % - 60 % by weight to function as a lubricant.

[0051] In accordance with another embodiment of the present subject matter, the halogen releasing component 402 is composed of a chlorine releasing compound such as trichloroisocyanric acid in the range of about 5% to 100% by weight, an additive such as boric acid in the range of about 0% to 90% by weight to function as a diluent to slow down the tablet dissolution rate, aluminum hydroxide in the range of about 0% to 50% by weight to function as another additive, cyanuric acid in the range of about 0% to 50% by weight to function as another additive to slow down the tablet dissolution rate, PVP K-30 in the range of about 0% - 60% by weight to function as a binder, and magnesium stearate in the range of about 0% - 60% by weight to function as a lubricant.

[0052] In accordance with yet another embodiment of the present subject matter, the halogen releasing component 402 is composed of sodium dichloroisocyanurate in the range of about 10 % to 50% by weight, calcium hypochlorite in the range of about 10 to 50 % by weight and magnesium stearate in the range of about 0 % to 60 % by weight to function as a lubricant.

[0053] Further, the halogen releasing component 402 may be produced in the form of the tablet by mixing all the aforementioned ingredients thoroughly, followed by grinding for about 10 to 20 min to get some fine powder. The fine powder may then be compressed in the form of a die at a pressure of about 1 to 10 tons. Alternatively, the tablet may also be made using an automated tablet making machine. In accordance with an embodiment, the weight of an individual tablet may be in the range of about 1 gram (gm) to 20 gm. In another embodiment, the weight of an individual tablet may be in the range of about 1 gm to 5 gm.

[0054] In operation, as the disinfected water enters the secondary disinfectant unit 118, it passes through the third inlet 206 into the base 408. The disinfected water then starts moving in an upward direction through the inlet passage 416 towards the halogen releasing component 402 as shown by an arrow 424 and reaches the central opening 418. The water then gets distributed into the radial channels as indicated by the arrows 420-1 and 420-2, touching and in a controlled way dissolving the bottom surface of the halogen releasing component 402. In operation, as the disinfected water enters the secondary disinfectant unit 118, it passes through the second inlet 206 into the base 408. The disinfected water then starts moving in an upward direction towards the halogen releasing component 402 through the inlet passage 416 as shown by an arrow 424. Subsequently, the disinfected water exits through the central opening 418 and gets distributed into the radial channels as indicated by the arrows 420-1 and 420-2, touching and, in a controlled way, dissolving the bottom surface of the halogen releasing component 402. The microorganisms that were not inactivated by the primary disinfectant unit 116 are thus inactivated by the halogen releasing component 402 to provide the purified water. Further, a controlled contact of the disinfected water with the halogen releasing component 402 ensures that a predetermined amount of the halogen is dosed into the disinfected water. In one embodiment, the halogen releasing component 402 is designed to release around 0.2 ppm of chlorine in a continuous flow of water at a flow rate of about 2 -6 liter per hour. The purified water thus obtained then comes down through the outlet passages 422, as indicated by arrows 426-1, 426-2 and exits the secondary disinfectant unit 118 through the second outlet 208. As the halogen releasing component 402 gets consumed, the spring 410 starts expanding, pushing the plunger 404 and the halogen releasing component 402 downwards.

[0055] Further, the shape, size and composition of the halogen releasing component 402 are designed such that the halogen releasing component 402 dissolves completely in a predefined volume of water. Thus giving an indication of life of the water purification device 104 to the user. As the halogen releasing component 402 gets consumed, the plug 406 comes in contact with the opening 418 and stops the flow of the disinfected water through it. At this point, untreated water stops flowing through the water purification device 104 and provides an indication for replacement of the water purification device 104. In one implementation, the halogen releasing component 402 may be replaced in the water purification device 104 instead of replacing the water purification device 104. Additionally, the casing 412 may be made using a transparent material to provide a visual indication of the life of the water purification device 104 and stoppage of water flow through the water purification device 104.

[0056] Stopping the purification process ensures that the water purification device 104 is not used beyond a safe prescribed limit thus ensuring that purified water received from the apparatus 100 is always safe for drinking. Further, the use of two stages of purification inactivates microbial contamination and also facilitates removal of various contaminants, for example, particulate matter may get removed due to the use of the porous media. Additionally, synergistic effect of the two different disinfectants, i.e., the metal disinfectant such as silver and the halogen such as chlorine at two stages of the purification process ensures that all the microbial contaminants present in the untreated water are inactivated. For example, most of Gram negative pathogens responsible for water borne disease e.g. *E. coli*, *Pseudomonas aeruginosa*, *Vibrio cholera*, *Salmonella typhi*, *Shigella dysenteriae* and *poliovirus* show sensitivity to silver and can thus be inactivated using silver as the disinfectant. Chlorine, on the other hand, can be used to inactivate Gram positive group of microorganisms, heterotrophic group of microorganism, and Hepatitis A virus present in the untreated water.

[0057] In addition, using two different disinfectants helps in purifying the untreated water using a small amount of the disinfectants, reducing the amount of residual disinfectants in the purified water. Reducing the amount of residual disinfectants helps in eliminating an extra step of removing excess residual disinfectants.

[0058] Fig. 5 illustrates a graph 500 depicting performance of the water purification device 104, according to an embodiment of the present subject matter. The graph 500 further depicts concentration of residual disinfectants in the purified water. In the graph 500, amount of water passed through the water purification device 104 is taken as a reference position and is represented along a horizontal axis 502, while log reduction of contaminants in the water, concentration of residual silver, and concentration of residual chlorine is represented on vertical axis 504-1, 504-2, and 504-3, respectively.

[0059] The graph 500 shows the results obtained after experiments were performed for testing performance of the water purification device 104. The water purification device 104 was tested at a flow rate of 3 – 3.5 liters per hour (L/hr) by passing up to 2288 liters of untreated water received by artificially spiking ground water with a bacterial culture *Escherichia coli (E. coli)* ATCC 11229 at a concentration of about 10^6 colony forming units per milliliter of water (CFU/ml). A sample of the untreated water was collected in a sterile container to check the input load. The output water, i.e., the purified water from the water purification device 104 was collected in a separate sterile container to determine its microbial load, i.e., to determine the effectiveness of the water purification device 104 in treating the untreated water. Further, the performance of water purification device 104 was evaluated by comparing the bacterial count in the purified water and the untreated water. It should be noted that even though the test has been performed by measuring bacteria count, it will be understood that other microorganisms can also be removed.

[0060] Curve 506 represents the log reduction of contaminants in the purified water received by purifying the untreated water provided to the water purification device 104. Curve 508 and curve 510 represent concentration of residual silver and concentration of residual chlorine, in the purified water respectively. Log reduction is a mathematical term which in the present case shows the relative number of live microbes eliminated from a medium, i.e., water by purification methods. For example, a "6-log reduction" means lowering the number of microorganisms by a million fold, that is, if a water sample has 1,000,000 pathogenic microbes per milliliter, a 6-log reduction would reduce the number of microorganisms to one per milliliter.

[0061] The graph 500 shows that the purified water is substantially free from bacterial contaminants with a reduction of input count by 6 logs for more than 2288 liters of water passed through the water purification device 104. Further, the low concentrations of silver and chlorine in the purified water are acceptable for human consumption even with respect to qualitative parameters, such as taste and odor, thus making the purified water fit for human consumption.

[0062] Although implementations of a water purification device have been described in language specific to structural features and/or methods, it is to be understood that the appended claims are not necessarily limited to the specific features or methods described. Rather, the specific features and methods are disclosed as implementations of the water purification device.

I/We Claim:

1. A water purification device (104) for purification of water, the water purification device (104) comprising:

    a primary disinfectant unit (116) comprising at least one silver treated porous media (302) to inactivate a first portion of microbial contaminants present in the water; and

    a secondary disinfectant unit (118) comprising at least one halogen releasing component (402) to inactivate a second portion of the microbial contaminants present in the water.

2. The water purification device (104) as claimed in claim 1, wherein the at least one silver treated porous media (302) comprises a purification media treated with a disinfectant, and wherein the disinfectant is one of a silver salt, a nano particle of silver, silver oxide, and silver hydroxide.

3. The water purification device (104) as claimed in claim 1, wherein the at least one silver treated porous media (302) comprises a purification media treated with silver, and wherein the purification media is at least one of a rice husk ash (RHA), clay, sand, foam, woven/nonwoven cloth, resin, activated carbon, charcoal powder, saw dust, ceramics, cellular plastics, zeolites, silicates, organosilicas, silicon, alumina, aluminosilicates, metals, metal foams, metal oxides, clay minerals, carbon nanotubes, synthetic and natural organic polymers, cloth fabrics, and fiber.

4. .The water purification device (104) as claimed in claim 3, wherein the at least one silver treated porous media (302) comprises a binder selected from a group consisting of polyvinyl alcohol, epoxy resin, gum, maltodextrin, lactose, polyvinylpyrrolidone (PVP), polyethylene, polypropylene, polyolefin, cellulose ethers, bentonite, and combinations thereof.

5. The water purification device (104) as claimed in claim 1, wherein the at least one halogen releasing component (402) comprises at least one halogen.

6. The water purification device (104) as claimed in claim 1, wherein the at least one halogen releasing component (402) comprises a chlorine releasing compound selected from a group consisting of calcium hypochlorite, sodium hypochlorite, sodium dichloroisocyanurate, chloramines-T, chlorinated tri sodium phosphate, lithium hypochlorite, trichloroisocyanuric acid, and combinations thereof.

7. The water purification device (104) as claimed in claim 1, wherein the at least one halogen releasing component (402) is a tablet.
8. The water purification device (104) as claimed in claim 7, wherein the tablet comprises of an additive selected from a group consisting of calcium sulphate, magnesium sulphate, calcium carbonate, magnesium carbonate, sodium persulphate, potassium phosphate, dibasic calcium phosphate, aluminium sulphate, ferric sulphate, adipic acid, boric acid, cyanuric acid, cellulose, starch, glucose, lactose, mannitol, sorbitol, and combinations thereof.
9. The water purification device (104) as claimed in claim 7, wherein the tablet comprises of a binder selected from a group consisting of sucrose, lactose, starch, cellulose, microcrystalline cellulose, hydroxypropyl cellulose, sorbitol, mannitol, gelatin, polyvinylpyrrolidone (PVP), PVP K-30, polyethylene glycol, and combinations thereof.
10. The water purification device (104) as claimed in claim 7, wherein the tablet comprises of a lubricant selected from a group consisting of talc, silica, sodium stearate, magnesium stearate, stearic acid, and combinations thereof.
11. The water purification device (104) as claimed in claim 7, wherein the tablet comprises,

    a chlorine releasing compound in the range of about 5 % to 100 % by weight, wherein the chlorine releasing compound is at least one of a calcium hypochlorite, sodium dichloroisocyanurate, and trichloroisocyanuric acid;

    calcium sulphate in the range of about 0 % to 90 % by weight;

    PVP K- 30 in the range of about 0 % to 60 % by weight; and

    magnesium stearate in the range of about 0 % to 60 % by weight.
12. The water purification device (104) as claimed in claim 7, wherein the tablet comprises,

    trichloroisocynuric acid in the range of about 5 % to 100 % by weight;

    boric acid in the range of about 0 % to 90 % by weight;

    aluminum hydroxide in the range of about 0% to 50% by weight;

    cyanuric acid in the range of about 0% to 50% by weight; and

    magnesium stearate in the range of about 0 % to 60 % by weight.
13. The water purification device (104) as claimed in claim 7, wherein the tablet comprises,

    sodium dichloroisocyanurate in the range of about 10 % to 50 % by weight;

    calcium hypochlorite in the range of about 10 % to 50 % by weight; and

    magnesium stearate in the range of about 0 % to 60 % by weight.

14. The water purification device (104) as claimed in claim 1, wherein the at least one silver treated porous media (302) releases a predetermined amount of silver in the water to have a residual concentration of less than 100 parts per billion.
15. The water purification device (104) as claimed in claim 1, wherein the at least one halogen releasing compound (402) releases a predetermined amount of a halogen in the water, wherein the predetermined amount of the halogen is in a range of 0.1 parts per million (ppm) to 0.5 ppm.
16. The water purification device (104) as claimed in claim 1, wherein the secondary disinfectant unit (118) comprises,

    a base (408) comprising,

        a second inlet (206) for receiving the water;

        an inlet passage (416) to carry the water from the second inlet (206) to a central opening (418);

        radial channels to allow passage of water from the central opening (418) and control dissolution of the at least one halogen releasing component (402);

        outlet passages (422) to carry the water from the radial channels to a second outlet (208); and

        supports (414) to rest the at least one halogen releasing component (402); and

    a casing (412) attached to the base (408) comprising,

        the at least one halogen releasing component (402);

        a plunger (404) with a plug (406) to hold the at least one halogen releasing component (402); and

        a spring (410) to support the plunger (404).

17. The water purification device (104) as claimed in claim 16, wherein the at least one halogen releasing component (402) is dissolved in a controlled way, and wherein on a complete dissolution of the at least one halogen releasing component (402), the plug (406) of the plunger (404) comes in contact with the central opening (418) to stop the flow of water into the water purification device (104).
18. The water purification device (104) as claimed in claim 1, wherein a first inlet (202) of the primary disinfectant unit (116) is connected to a source reservoir (102) to receive the water

for disinfecting, and wherein a first outlet (204) of the primary disinfectant unit (116) is connected to a second inlet (206) of the secondary disinfectant unit (118) to provide disinfected water to the secondary disinfectant unit (118) for purification.

19. The water purification device (104) as claimed in claim 1, wherein a second inlet (206) of the secondary disinfectant unit (118) is connected to a source reservoir (102) to receive the water for disinfecting, and wherein a second outlet (208) of the secondary disinfectant unit (118) is connected to a first inlet (202) of the primary disinfectant unit (116) to provide disinfected water to the primary disinfectant unit (116) for purification.

20. The water purification device (104) as claimed in claim 1, wherein the at least one silver treated porous media (302) is formed by exposing RHA to silver by a method selected from passing a silver solution through a bed of RHA, soaking the RHA in the silver solution, spraying the silver solution on the RHA, painting the silver on the RHA, and in-situ synthesis of nano silver within the RHA.

21. A method for purification of water for consumption comprising:

inactivating a first portion of microbial contaminants present in the water using at least one silver treated porous media; and

inactivating a second portion of the microbial contaminants present in the water using at least one halogen releasing component, wherein the at least one halogen releasing component releases a predetermined amount of a halogen to keep a concentration of the halogen below a predefined value.

22. The method as claimed in claim 21, wherein the method comprises releasing a predetermined amount of silver to have a residual concentration of less than 100 parts per billion.

23. The method as claimed in claim 21, wherein the predetermined amount of the halogen is in a range of 0.1 parts per million (ppm) to 0.5 ppm.

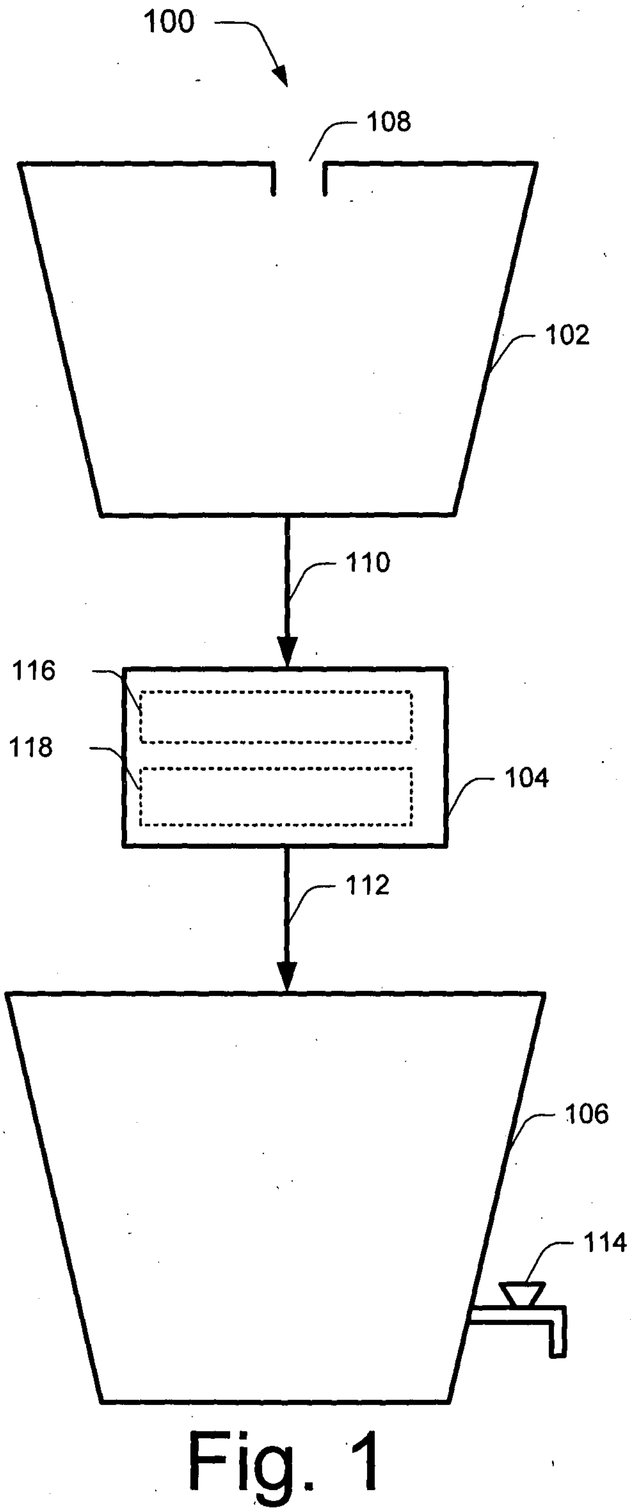


Fig. 1

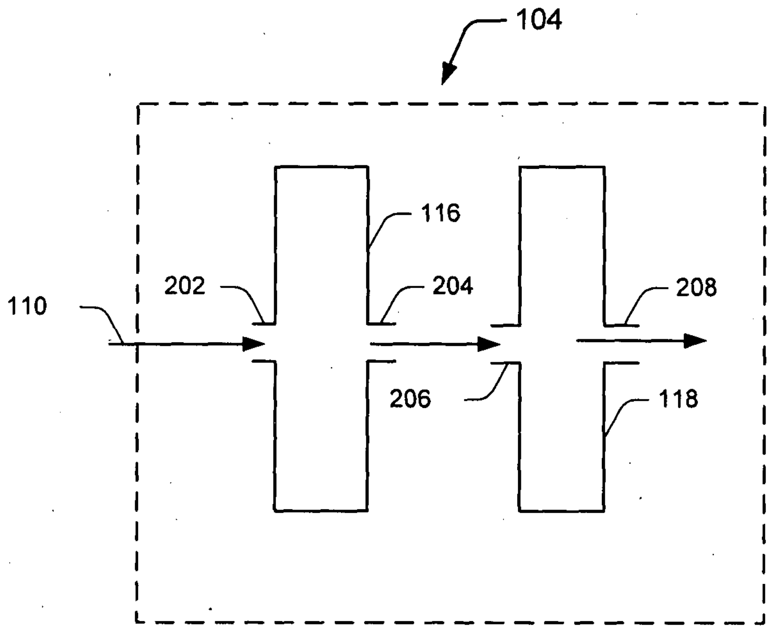


Fig. 2(a)

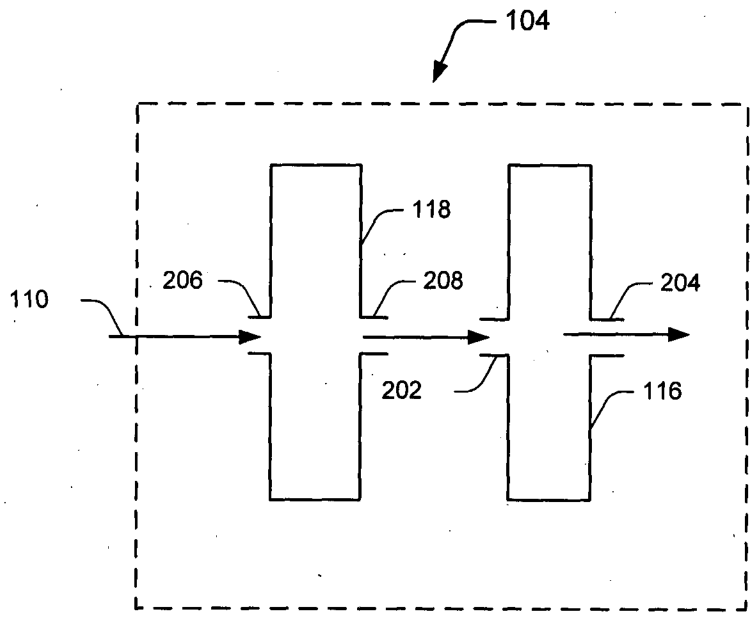


Fig. 2(b)

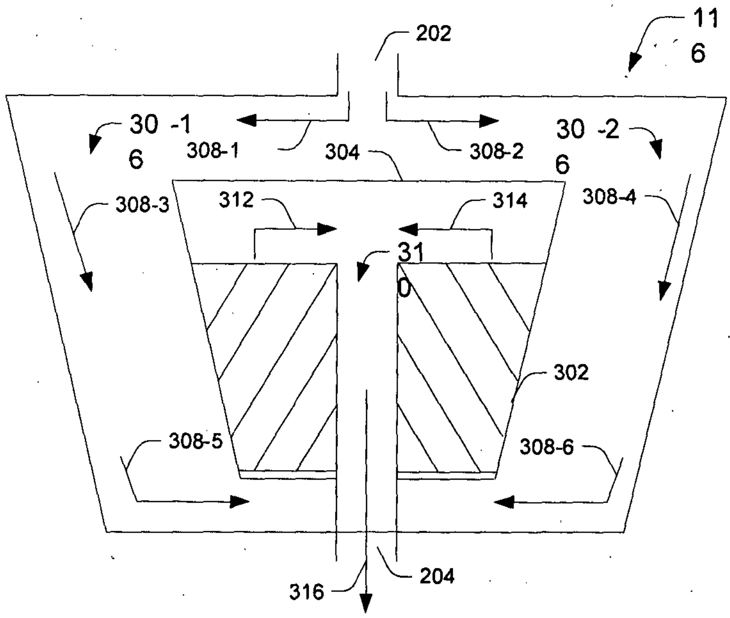
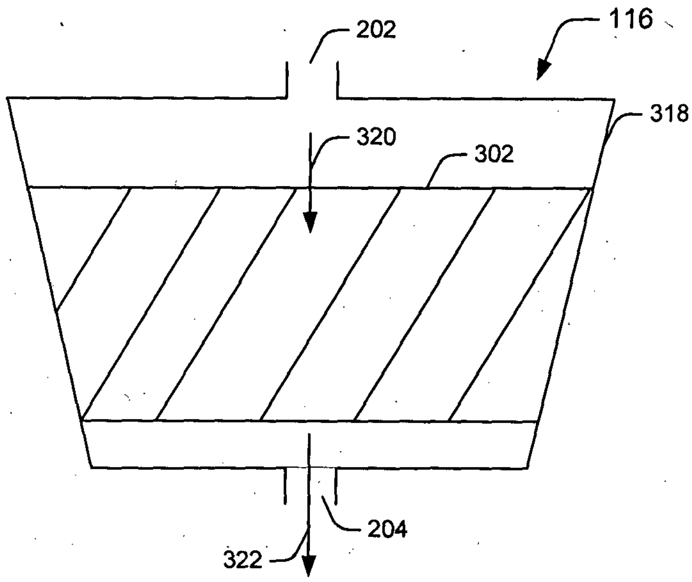

202
116
306-1
308-1
304
308-2
306-2
308-3
312
314
308-4
310
302
308-5
308-6
316
204

Fig. 3(a)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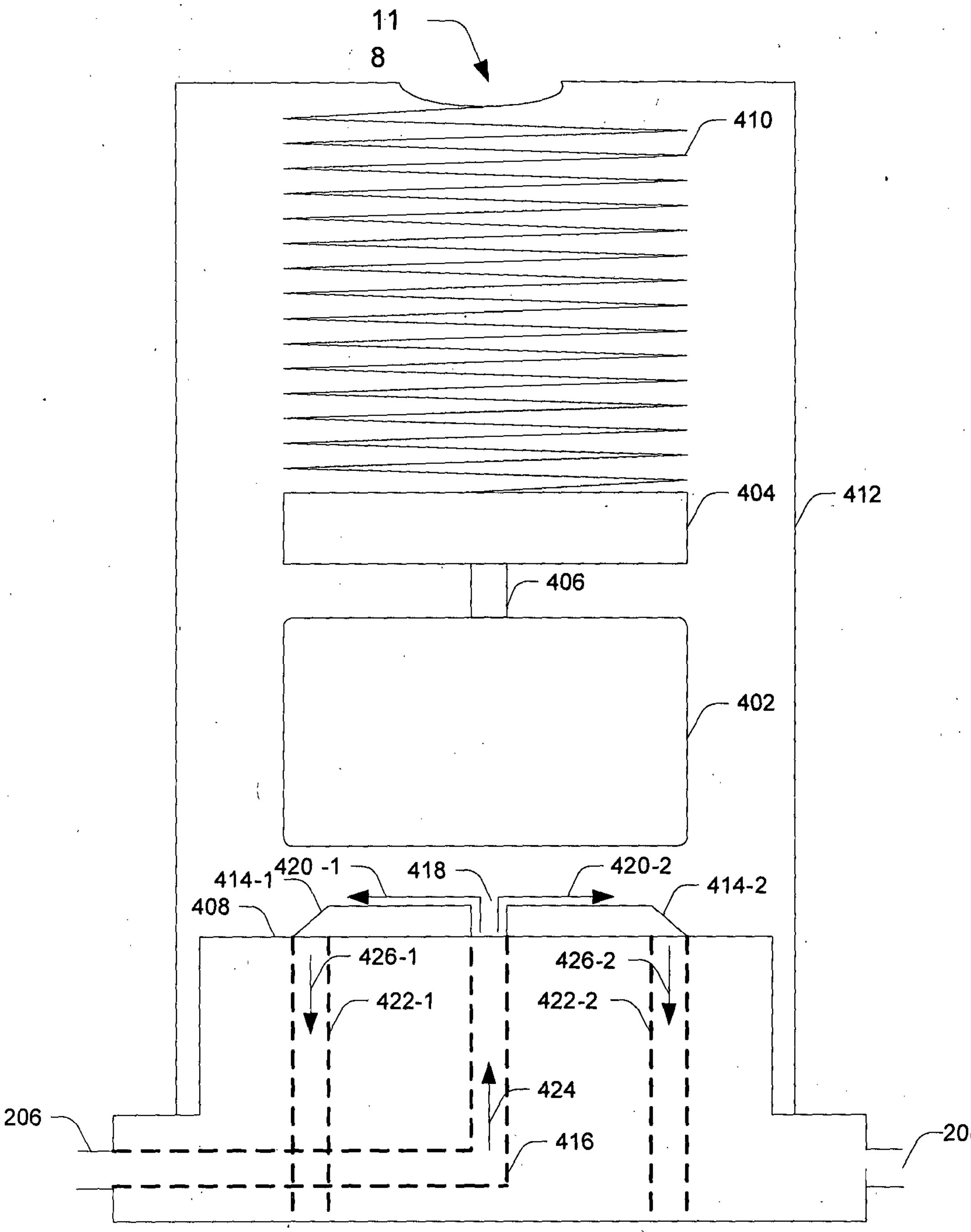
320
302
204
322

Fig. 3(b)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8
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426-1
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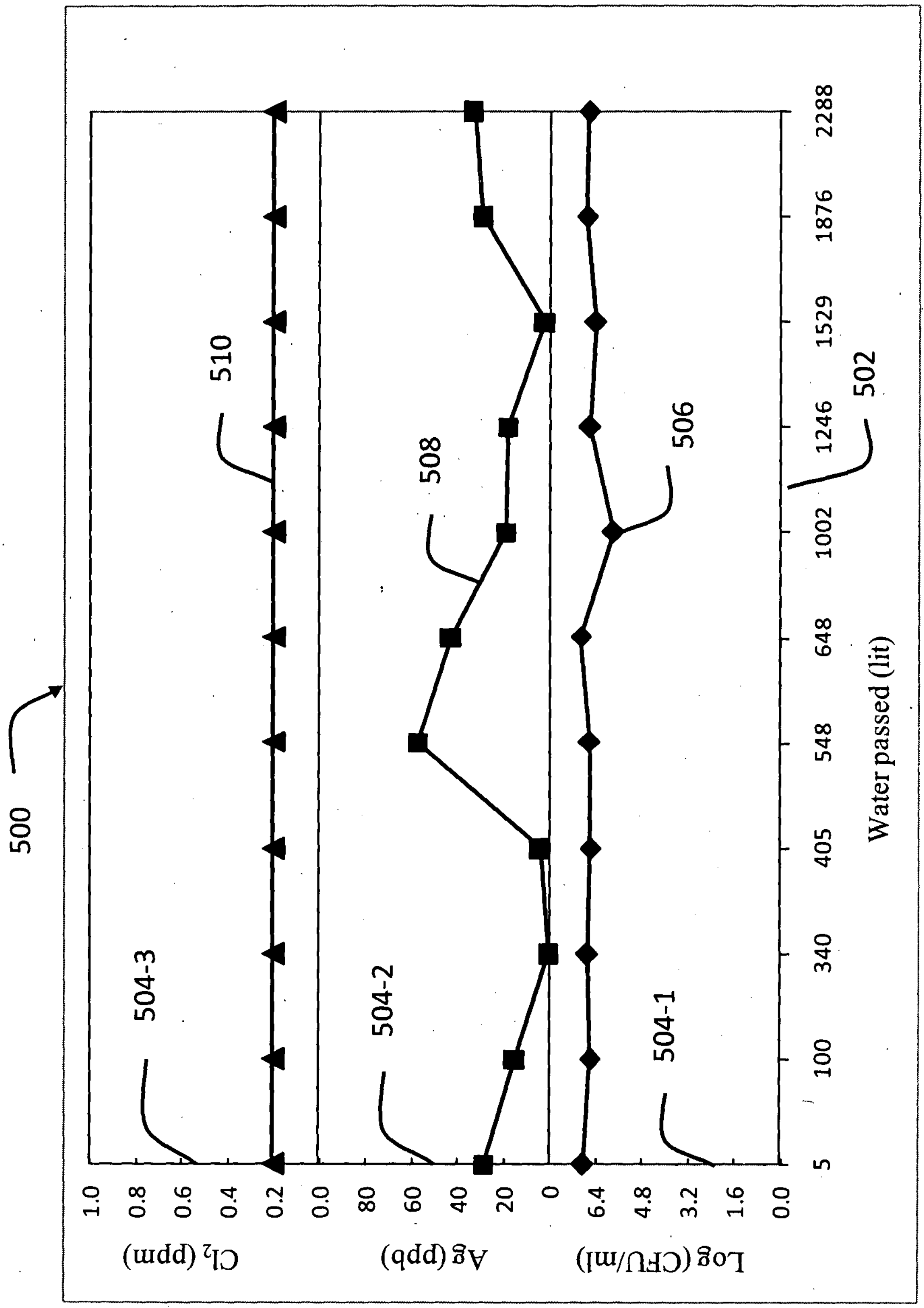
422-1
422-2
424
206
416
208

Fig. 4


500
510
508
506
502
504-3
504-2
504-1
Cl2 (ppm)
Ag (ppb)
Log (CFU/ml)
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0.6
0.4
0.2
0.0
80
60
40
20
0
6.4
4.8
3.2
1.6
0.0
5
100
340
405
548
648
1002
1246
1529
1876
2288
Water passed (lit)

Fig. 5