(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 March 2012 (08.03.2012)

PCT

(10) International Publication Number
WO 2012/031067 A2

(51) International Patent Classification:
B01D 24/02 (2006.01)

(21) International Application Number:
PCT/US2011/050133

(22) International Filing Date:
1 September 2011 (01.09.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/379,779 3 September 2010 (03.09.2010) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ,

[Continued on next page]

(54) Title: WATER FILTRATION DEVICE AND METHOD OF USING THE SAME

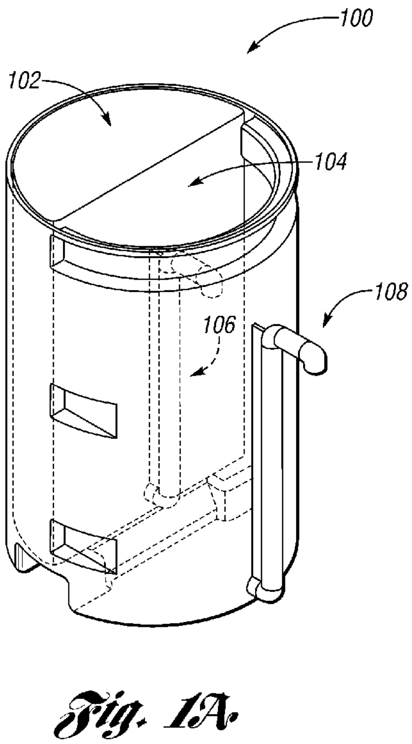

Fig. 1A.

(57) Abstract: In one embodiment, the water filtration device includes a first chamber including a first plurality of inorganic particles; and a second chamber in water communication with the first chamber. The second chamber further includes a second plurality of inorganic particles. In yet another embodiment, the first and second pluralities of inorganic particles are each independently selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatious earth zeolite, and combinations thereof. In certain instances, the first and second chambers further independently include sand. The water filtration device may be portable or of a stationary size for community use.

WO 2012/031067 A2

TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

WATER FILTRATION DEVICE AND METHOD OF USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[1] This application claims the benefit of U.S. provisional application Serial No. 61/379,779, filed September 3, 2010, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[2] One or more embodiments of the present invention relate to water filtration device and method of using the same.

BACKGROUND

[3] There has been a constant need for improved drinking water, particularly for remote areas of the developing world where people live without access to safe water for drinking, cooking and bathing. Lack of clean water contributes to pediatric diarrheal diseases and associated casualties, among others.

SUMMARY

[4] According to one aspect of the present invention, there is provided a water filtration device. In one embodiment, the water filtration device includes a first chamber including a first plurality of inorganic particles; and a second chamber in water communication with the first chamber. In certain instances, the second chamber further includes a second plurality of inorganic particles.

[5] In another embodiment, the water filtration device further includes a first discharge conduit including a first inlet and a first outlet, wherein water is transported from the first chamber via the first inlet to the second chamber via the first outlet. In certain instances, the first outlet of the first discharge conduit is positioned above a first base of the first chamber with a first distance such that water in the first chamber has a first pre-determined dwell time prior to exiting through the first outlet.

[6] In yet another embodiment, the water filtration device further includes a second discharge conduit including a second inlet and a second outlet, wherein water is transported from the second chamber via the second inlet and exits the second discharge conduit via the second outlet. In certain instances, the second outlet of the second discharge conduit is positioned lower than the first outlet of the first discharge conduit with a conduit distance, and wherein second outlet of the second discharge conduit is positioned higher than a second base of the second chamber with a second distance such that water in the second chamber has a second predetermined dwell time prior to exiting through the second outlet.

[7] In yet another embodiment, the first and second pluralities of inorganic particles are each independently selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatious earth zeolite, and combinations thereof. In certain instances, the first and second chambers further include non-porous inorganic particles such as sand.

[8] In yet another embodiment, one or both of the first and second chambers further include a biocide, a toxic metal absorber, and/or a pH modifier. In certain instances, the first and second chambers each include a biocide.

[9] In yet another embodiment, the first and second chambers each further independently include a biocide selected from the group consisting of copper-containing biocide, silver-containing biocide, a zinc-containing biocide, a halogen-containing biocide, a bromine containing biocide, a nickel-containing biocide, an aluminum-containing biocide, and combinations thereof. In certain instances, the first and second chambers each include the biocide, and the composition of the biocide may be the same or different between the first and second chambers. The first and second chamber each may further independently include a cation detergent, an organic acid, and combinations thereof. In certain instances, the biocide includes ground silver, silver alloys, colloidal silver, silver nitrate, silver dehydrate, ground copper, copper alloys, copper sulfate, ground zinc, zinc alloys, brass, iodine, zinc chloride, zinc oxide, benzalkanium chloride, cetylpyridinium chloride, sorbic acid, benzoic acid, or combinations thereof.

[10] In yet another embodiment, the first and second pluralities of inorganic particles each independently pass no less than 95 percent through a number #5 sieve and are retained no less than 95 percent on a number #30 sieve. In certain instances, the inorganic particles pass no less than 95 percent on a number #24 sieve and retain no less than 95 percent on a number #48 sieve. In certain other instances, the inorganic particles pass no less than 95 percent on a number #10 sieve and retain no less than 95 percent on a number #20 sieve. In yet other instances, the inorganic particles pass no less than 95 percent on a number ½″ (inch) sieve and retain no less than 95 percent on a number #6 sieve.

[11] The inorganic particles may be of any suitable shape. Non-limiting examples of the shape of the inorganic particles include granules, powders, flakes, rods, chunks, cubes, balls, cubes, columns, and combinations thereof.

[12] In yet another embodiment, the water filtration device may be portable or stationary. The stationary version of the water filtration device may be used for community use, or these devices can be termed community devices. When designed as portable, the water filtration device may have a dimension selected from the group consisting of a longitudinal length of between 15 to 36 inches, a total dry weight of 25 to 200 pounds, a cross-section of 10 to 24 inches in diameter, and combinations thereof. When designed as stationary, the water filtration device may have a dimension selected from the group consisting of a longitudinal length of between 30 to 110 inches, a total dry weight of 120 to 8000 pounds, a cross-section of 20 to 60 inches in diameter, and combinations thereof.

[13] In yet another embodiment, the water filtration device further includes a diffuser to diffuse flow of water onto the first plurality of inorganic particles. In certain instances, a filter may be closely positioned relative to the diffuser such that water comes in contact with filter prior to exiting through the diffuser. In this regard, the filter can be viewed as a large debris strainer or collector.

[14] In yet another embodiment, the first chamber has a first water filtration volume and the second chamber has a second water filtration volume, the second water filtration volume is equal to, less than, or greater than the first water filtration volume.

[15] In yet another embodiment, the water filtration device includes a chamber having an inlet and an outlet together defining a water treatment volume, the chamber including a plurality of inorganic particles selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatious earth zeolite, and combinations thereof; and a filtration supplement including a biocide and/or a toxic metal absorber. In certain instances, the toxic metal absorber is selected from the group consisting of iron oxide, manganese oxide, bone meal, iron ore, metal fillings, positively and negatively charged resins, granular activated carbon and combinations thereof.

[16] According to another aspect of the present invention, a method is provided for providing water for domestic consumption. The method includes the step of communicating raw water to a water filtration device according to one or more embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[17] Figures 1A-1H depict various views of a water filtration device in one or more embodiment;

[18] Figure 2 depicts a cross-sectional view of a variation to the water filtration device of Figures 1A-1E;

[19] Figure 3 depicts a cross-sectional view of another variation to the water filtration device of Figures 1A-1E;

[20] Figure 4 depicts a cross-sectional view of yet another variation to the water filtration device of Figures 1A-1E;

[21] Figure 5 depicts a cross-sectional view of yet another variation to the water filtration device of Figures 1A-1E;

[22] Figure 6 depicts a cross-section view of a variation to the water filtration device of Figure 5;

[23] Figure 7 depicts a cross-sectional view of a variation to the water filtration device of Figure 1E;

[24] Figure 8A depicts a cross-section view of a water treatment device according to one or more other embodiments;

[25] Figure 8B depicts a cross-section view of a variation to the water treatment device of Figure 8A;

[26] Figure 9 depicts a cross-section view of a water treatment device according to one or more other embodiments;

[27] Figures 10A and 10B depict micrograph images showing entrapment of bacterial by the porous ceramic particles; and

[28] Figure 11 depicts a method flow chart for providing drinking and cooking water.

DETAILED DESCRIPTION

[29] As required, detailed embodiments of the present invention are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for the claims and/or a representative basis for teaching one skilled in the art to variously employ the present invention.

[30] Moreover, except where otherwise expressly indicated, all numerical quantities in the description and in the claims are to be understood as modified by the word "about" in describing the broader scope of this invention. Unless expressly stated to the contrary, the description of a group or class of material is suitable or preferred for a given purpose in connection with the invention implies that mixtures of any two or more members of the group or class may be equally suitable or preferred.

[31] In one or more embodiments, the present invention provides a cost-efficient and environmental friendly water filtration device particularly suitable for "point of use" applications in the household water treatment sector. As will be detailed below, the water filtration device filters and treats raw water to produce drinking and cooking water for individual families and particularly for a family of 4 to 6. The water filtration device may be presented in a portable singular device and may be placed wherever drinking and cooking water consumption is desirable. Moreover, the water filtration device may be designed and constructed to be operable independent of external support of energy such as electrical energy. Thus, the water filtration device may be used in certain parts of the developing world in need of drinking water yet with limited sources of energy.

[32] In one or more embodiments, the term "raw water" refers to a water source that contains various types of organic matter, sediment, and/or disease-causing pathogens. Non-limiting examples of the disease-causing pathogens include bacteria, viruses, protozoa, and helminthes (parasitic worms).

[33] According to one aspect of the present invention, and as depicted in Figures 1A-1H, a water filtration device is generally shown at 100. Figure 1A illustratively depicts a perspective view of the water filtration device 100. Figure 1B illustratively depicts a cross-sectional view of the water filtration device 100. Figure 1C illustratively depicts another cross-sectional view of the water filtration device 100. Figure 1D illustratively depicts a top view of the water filtration device 100. As will be detailed herein elsewhere, the water filtration device 100 can be of any suitable shape, and is not limited to the cylindrical shape depicted in Figures 1A-1D.

[34] Figure 1E depicts an enlarged view of Figure 1B to show various structural elements with greater clarity. As depicted in Figure 1E, the water filtration device 100 includes a first chamber 102 including a first plurality of inorganic particles 114; and a second chamber 104 in water communication with the first chamber 102. In yet another embodiment, the second chamber 104 includes a second plurality of inorganic particles 116.

[35] In one or more embodiments, the first chamber 102 optionally refers to a bio-remediation chamber or a first (1^{st}) stage; and the second chamber 104 optionally refers to a biocidal-remediation chamber, or a second (2^{nd}) stage.

[36] Although only one first chamber 102 and one second chamber 104 are specifically depicted in Figures 1A-1E, it is noted that the first/bio-mediation stage may optionally include two or more first chambers 102, and the second/biocidal stage may optionally include two or more second chambers 104. When employed, multiple first chambers 102 and/or second chambers 104 may be arranged in serial relationship to one another. For instance, and as depicted in Figure 7, a water filtration device generally shown at 100 varies from the water filtration device of Figure 1E by having a third chamber 740 downstream to and in water communication with the second chamber 104. Relative sizes between the first, second, and third chambers can be any suitable values dependent upon the particular water filtration project at hand. Generally, the three-chamber configuration according to Figure 7 may be particularly suitable for treating raw water with added anti-microbial filtration and protection.

[37] The first chamber 102 and the second chamber 104 may each independently be of any suitable shapes. Non-limiting examples of the suitable shapes for the first and second chambers 102, 104 include cylinders, elongated cylinders, cubes, elongated cubes, pyramids, elongated pyramids, ovals, and elongated ovals.

[38] In yet another embodiment, and as depicted in Figure 1E, the water filtration device 100 further includes a first discharge conduit 106 having a first inlet 106a and a first outlet 106b, wherein water is transported from the first chamber 102 via the first

inlet 106a to the second chamber 104 via the first outlet 106b. In certain instances, and as depicted in Figure 1E, the first outlet 106b is positioned above the first inlet 106a with a first distance "L1" such that water inside the first chamber 102 is provided with a first pre-determined amount of dwell time prior to exiting out of the first chamber 102. In operation, and as depicted in Figure 1E, as long as a top water surface 122 is maintained at or below the lowest point 106c of the first outlet 106b, there is no water discharge from the first chamber 102, to ensure a desirable dwell time for the water.

[39] In yet another embodiment, and as depicted in Figure 1E, the water filtration device further includes a second discharge conduit 108 having a second inlet 108a and a second outlet 108b, wherein water is transported from the second chamber 104 via the second inlet 108a and exits out of the second chamber 104 via the second outlet 108b. In certain instances, and as depicted in Figure 1E, the second outlet 108b is positioned above the second inlet 108a with a second distance "L2" such that water inside the second chamber 104 is provided with a second pre-determined amount of dwell time prior to exiting out of the second chamber 104. In operation, and as depicted in Figure 1E, as long as a top water surface 124 within the second chamber is maintained at or below the lowest point 108c of the second outlet 108b, there is no water discharge from the second chamber 104, to ensure a desirable dwell time of the water.

[40] In certain instances, at least a portion of the first and second discharge conduits 106, 108 each independently have an interior cross-sectional diameter of 0.125 to 0.75 inches, 0.25 to 0.5 inches, 0.25 to 0.375 inches, or 0.375 to 0.5 inches.

[41] In certain instances, the first pre-determined dwell time is optionally controlled and/or adjusted by modulating the incoming flow rate of the raw water. For instances, the raw water may be stored in a raw water reservoir having a raw water outlet with a flow rate control. In this design, an end user may adjust the flow rate control to have a desirable volume of raw water introduced into the first chamber 102, such that the requisite dwell time is ensured with regard to the desirable volume of raw water.

[42] Within the spirit of the water filtration device being employed for "point of use" and being of relatively light weight for portable use, an interior treatment volume "V1" and "V2" of the first and second chambers 102, 104 may independently be of any suitable values. In certain instances, the first interior treatment volume V1 generally represents the loading volume of the first plurality of inorganic particles 114; the second interior treatment volume V2 generally represents the loading volume of the second plurality of inorganic particles 116. The first and second treatment volumes "V1" and "V2" are each independently of 1,500 to 4,500 cubic inches, 2,000 to 4,000 cubic inches, 2,500 to 3,500 cubic inches, 1,500 to 2,000 cubic inches, 2,000 to 2,500 cubic inches, 2,500 to 3,000 cubic inches, 3,000 to 3,500 cubic inches, 3,500 to 4,000 cubic inches, or 4,000 to 4,500 cubic inches.

[43] Within the spirit of the water filtration device being employed for "point of use" and being of relatively light weight for portable use, a height "L" of the water filtration device 100, along with "L1" and "L2" as described herein, may have any suitable values. In certain instances, the device height "L" is of from 17 to 36 inches, 18 to 32 inches, 19 to 28 inches, 20 to 24 inches, or 21 to 23 inches. The first conduit discharge height "L1" is of from 10 to 30 inches, 11 to 27 inches, 12 to 24 inches, 13 to 21 inches, or 14 to 18 inches. The second conduit discharge height "L2" is of from 8 to 27 inches, 9 to 23 inches, 10 to 19 inches, 11 to 16 inches, or 12 to 14 inches.

[44] In one or more embodiments, the first and second pluralities of inorganic particles 114, 116 may each independently include one or more types of porous particles such as porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatiousearthzeolite, and combinations thereof. In certain instances, the first and second pluralities of inorganic particles 114, 116 each independently include porous ceramic particles.

[45] Suitable porous particles include those commercially available as Profile Porous Ceramic particles by Profile Products, LLC of Buffalo Grove, IL. These porous ceramic particles are clay-based montmorillonite particles, optionally mined from Blue Mountain, Missouri (MS), and fired to high temperatures such as 1000° C to make a

porous ceramic particle. In certain instances, the porous ceramic particles pass no less than 95 percent on a number #5 sieve and retain no less than 95 percent on a number #30 sieve. These particles are alternatively termed “5x30” particles. In certain other instances, the porous ceramic particles pass no less than 95 percent on a number #24 sieve and retain no less than 95 percent on a number #48 sieve. These particles are alternatively termed “24x48” particles. In yet other instances, the porous ceramic particles pass no less than 95 percent on a number #10 sieve and retain no less than 95 percent on a number #20 sieve. These particles are alternatively termed “10x20” particles. In yet other instances, the porous ceramic particles pass no less than 95 percent on a number ½″sieve and retain no less than 95 percent on a number #6 sieve. These particles are alternatively termed “½″x6” particles.

[46] Non-limiting examples for the 5x30, 10x20, 24x48, and ½″x6 porous ceramic particles include porous ceramic particles under the trade name of “MVP”, “Field and Fairway”, “Greens Grade”, and “Orchid Mix”, respectively, available from Profile Products, LLC of Buffalo Grove, IL. Non-limiting particle distribution values for these particles are tabulated in Tables 1A and 1B below.

[47] Table 1A

	Percentages of particles collected on sieves in millimeters (mm)					
	2 mm	1 mm	0.5 mm	0.25 mm	0.15 mm	0.05 mm
MVP 5x30	55-63	35-43	1.5-2.5	0.1-0.5	0.05-0.2	0.05-0.2
Pro League	18-24	67-73	5.0-7.0	0.2-0.6	0.1-0.3	0.05-0.2
Field & Fairway 10x20	less than 0.5	32-38	41-47	17-23	0.05-0.2	0.05-0.2
Greens Grade 24x48	less than 0.5	0.05-0.2	52-67	37-44	0.05-0.4	0.05-0.4

Table 1B

	Percentages of particles collected on sieves in millimeters (mm)					
	9.5mm	8.0 mm	6.3 mm	3.4 mm	1.7 mm	<1.7 mm
Orchid Mix 1/2´´x6	5-20	12-27	25-33	25-45	0.5-3	2-7

[48] Average pore size of the porous particles can be of any suitable values. In certain instances, average pore size range from 0.1 to 20 microns, 0.5 to 18 microns, 1.0 to 16 microns, 2.0 to 14 microns, 2.5 to 12 microns, 3.0 to 10 microns, 3.5 to 8 microns, 0.5 to 2.5 microns, 2.5 to 5.0 microns, 5.0 to 7.5 microns, 7.5 to 10.0 microns, 10.0 to 12.5 microns, 12.5 to 15.0 microns, 15.0 to 17.5 microns, or 17.5 to 20.0 microns in diameter.

[49] In certain instances, the porous ceramic particles are provided with an average surface area as indicated in Table 2 below, in comparison to several types of sand.

[50] Table 2

Particle Type	Diameter (millimeters)	Estimated Average Surface Area (square meters per gram of dry weight)
Coarse Sand	1.0 to 0.5	20
Profile Porous Ceramic (PPC) Particles	1.0 to 0.25	>1,000
Medium Sand	0.5 to 0.25	50
Fine Sand	0.25 to 0.05	100
Very Fine Sand	0.10 to 0.05	250

[51] In certain other instances, the porous ceramic particles have a cation exchange capacity (CEC) range of 1-200 milli-equivalent per 100g (meq/100g), 2-100 meq/100g, 5 to 50 meq/100g, 10 to 30 meq/100g, 15 to 25 meq/100g, or any combinations thereof. In certain other instances, the porous ceramic particles have a total porosity of 50 to 90 % or 70 to 85 %, with a total capillary porosity of 30 to 50 % or 37 to 45 %, and a total non-capillary porosity of 25 to 50% or 30 to 40 %. In certain other instances, the porous ceramic particles have a density of 0.45 to 0.75, 0.55 to 0.65 grams of dry weight per cubic centimeter.

[52] Referring back the Cation Exchange Capacity of the particles, and without wanting to be limited to any particular theory, it is believed that the metals oxidize and exchange cations of silver, copper and zinc with the water on the cation exchange sites within the porous ceramic particles. This so called "Cation web Matrix Theory" explains why the devices described according to one or more embodiments of the present invention become more effective over time even though the exchange of ions within the water doesn't change. It is believed that about 120 to 150 million particles per device can be charged with metal ions that, when contacted by the microorganisms moving through, exchange with the cell membrane and deactivate the passing through organisms. To expand on this, the microorganisms themselves may contribute to the development of a Cation Web within out particles. Their carcasses entrapped within the particles, adsorb the metal cations, further enhancing the organism deactivation effectiveness within the device.

[53] Without wanting to be limited to any particular theory, it is believed that the pores present within the inorganic particles 114, 116 help damage the pathogens. For instance, as gravity carries water through the water filtration device, pathogens are forced into the pore space, get entrapped therein, where the pathogens may be starved for oxygen and nutrition, contacted by metal cations and become deactivated. Figures 11A and 11B are micrograph images showing entrapment of bacteria within the porous by and/or within the porous ceramic particles.

[54] In yet another embodiment, and as depicted in Figure 1E, the water filtration device 100 further includes a diffuser 126 for diffusing raw water prior to its entry onto the inorganic particles 114. The diffuser 126 is optionally spaced apart from the first plurality of inorganic particles 114. Without wanting to be limited to any particular theory, it is believed that the diffuser 118 functions to reduce raw water inflow energy and help reduce flow disturbance at or near the surface layers of the inorganic particles 114. The diffuser 126 is optionally a mesh or a screen and can be of any suitable material. Non-limiting examples of the material for the diffuser 126 include metal, metal alloy, plastic, polymer, natural or synthetic polymer, or combinations thereof. In certain instances, the water filtration device 100 may further include a filter such as a fine filtration screen

and/or a filter cloth to be incorporated within the diffuser, optionally together with a debris strainer, as an extra level of filtration, to provide an enhanced level of performance than simply reducing water inflow energy.

[55] In yet another embodiment, and as depicted in Figure 1F, the first and second outlets 106b, 108b of the water filtration device may each independently be provided a turn portion 106c, 108c, respectively. In certain particular instances, the turn portion 106c, 108c is of an angle of 80 to 100 degrees, or 85 to 95 degrees, relative to the first and second inlets 106a, 108a. Without wanting to be limited to any particular theory, it is believed that turn portions 106c and 108c may help reduce clogging of the first and second inlets 106a, 108a due to debris and waste residues in the vicinity.

[56] In yet another embodiment, and as depicted in Figure 1F, the first and second chambers 102, 104 may each independently include first and second lower portions 144, 146. In certain instances, the lower portions 144, 146 may contain one or more layers of inorganic particles with relatively larger sizes, such as the ½´´x6 or the "Orchid Mix" particles. In certain other instances, the first and second lower portions 144, 146 may be separated from and defined by first and second water permeable separating layers 148, 150 disposed within the first and second chambers 102, 104, respectively. However, it is appreciated that the water permeable separating layers 148, 150 are only optional and not necessarily needed. The first and second separating layers 148, 150 may be of any suitable material permeable to water and non-permeable to debris, waste residues, or inorganic particles 114, 116. Non-limiting example of the suitable material for the first and second separating layers 148, 150 may include metal, metal alloy, plastic, polymer, natural or synthetic fabrics such as geotextiles and/or related composites. In certain instances, geotextiles are permeable fabrics capable of separating, filtering, reinforcing, or draining. Without wanting to be limited to any particular theory, it is believed that positioning the first and second inlets 106a, 108a within the first and second lower portions 144, 146, protected by the first and second separating layers 148, 150 helps reduce system clogging and help prolong the operable lifetime of the device.

[57] In yet another embodiment, and as depicted in Figure 1G, the first and second outlets 106b, 108b may have an enlarged end portion 106d, 108d each covered with a filter layer 106e, 108e of materials and performing functions similar to the separating layers 148, 150.

[58] In yet another embodiment, and as depicted in Figure 1H, first and second top portions 152, 156 of the first chamber 102 and first and second bottom portions 154, 158 of the second chamber each independently include a plurality of inorganic particles having an average particle size greater than the average particle size of the first and second pluralities of inorganic particles 112, 114. This design may help provide greater sediment entrapment and easier device maintenance. In this design, the top and bottom portions 152, 156, 154, 158 may each independently include more than one variety of inorganic particles as long as an average particle size thereof is greater than the average particle size of the inorganic particles in the bulk of the chambers 102, 104. For instance, the top and bottom portions 152, 156, 154, 158 may each independently include porous ceramic particles 5x30 and 10x20 while the bulk includes porous ceramic particles 24x48.

[59] In a variation, the top and bottom portions 152, 156, 154, 158 may each independently include a particle supporting matrix to reduce the mobility of relatively larger inorganic particles and to further improve entrapment of debris and waste organism. Non-limiting examples of the particle supporting matrix include synthetic and/or non-synthetic fiber mesh. Particularly useful examples of the fiber mesh structures may include those used as turf control mats (TCM) derived from nylon or polymer fibers as an interconnected matrix. Some particular examples of the TCM structures useful for this design include three dimensional mats under the trade name of “Enkamat” marketed by Colbond USA, headquartered in the Netherlands.

[60] In one or more embodiments, the inorganic particles 114, 116 may be of any suitable shapes. Dependent upon particular water-drinking needs, the inorganic particles 108 may be designed and constructed in one or more shapes including gravel, granules, grains, flakes, rods, powders, cylinders, pyramids, cubes, and combinations thereof, and in various dimensions thereof.

[61] As can be seen from the non-limiting design of the water filtration device 100 depicted in Figures 1A-1E, water flow within the first and second chambers 102, 104, and water flow from the first chamber 102 to the second chamber 104 may each be independently driven by gravity. Therefore, the water filtration device 100 can be utilized in certain areas of the developing world where external energies such as electrical energies are limited in source and/or by economic concerns.

[62] In yet another embodiment, the first and second chambers 102, 104 may each independently include a biocide 140. In certain instances, the first and second chambers 102, 104 both include a biocide 140.To balance between filtration efficacy and material and implementation costs, and in certain instances, the biocide 128 may only be included in second chamber 104 and not in the first chamber 102. The biocide 128 may be disposed in any suitable portions of the second chamber 104. In certain instances, and as depicted in Figure 1E, the biocide 128 is intermixed with the second plurality of inorganic particles 116. In certain instances, the biocide 128 includes an agent selected from the group consisting of copper-containing biocide, silver-containing biocide, a zinc-containing biocide, a halogen-containing biocide, a cation detergent, an organic acid, and combinations thereof. In certain instances, the biocide 128 includes ground silver, silver alloys, colloidal silver, silver nitrate, silver dehydrate, ground copper, copper alloys, copper sulfate, ground zinc, zinc alloys, brass, iodine, zinc chloride, zinc oxide, benzalkanium chloride, cetylpyridinium chloride, sorbic acid, benzoic acid, or combinations thereof. In certain instances, the biocide includes one or more of zinc, copper and silver. In certain particular instances, and when employed, silver and copper as present in the biocide have a silver/copper weight ratio of 0.001 to 0.020 or 0.005 to 0.015. In certain other particular instances, and when employed, zinc to copper as present in the biocide have a zinc/copper weight ratio of 0.05 to 0.20 or 0.10 to 0.15. In certain other particular instances, and when employed, silver and zinc as present in the biocide have a silver/zinc weight ratio of 0.025 to 0.015 or 0.05 to 0.01.

[63] In certain particular instances, the biocide 128 includes particles of silver, copper, and/or zinc in the shapes of, for instances, rods, needles, flakes, granules, and

combinations thereof. In yet other particular instances, at least a portion of the silver, copper, and/or zinc particles each independently pass no less than 95 percent a size #10sieve and retain no less than 95 percent on a size #200 sieve. In yet other particular instances, at least a portion of the silver, copper, and/or zinc particles each independently pass no less than 95 percent a size #16 sieve and retain no less than 95 percent on a size #150 sieve. In yet other particular instances, at least a portion of the silver, copper, and/or zinc particles each independently pass no less than 95 percent a size #25 sieve and retain no less than 95 percent on a size #100 sieve.

[64] Without wanting to be limited to any particular theory, it is believed that positively charged ions of certain metals such as copper, silver and zinc attract and bond to the negatively charged cell walls of the pathogenic organisms. It is further believed that copper and zinc ions destroy permeability of the pathogenic cell walls; and silver ions enter the pathogenic organisms, interfering with protein enzyme synthesis. In most instances, damage to the cell walls alone may be sufficient to deactivate the pathogenic organisms.

[65] Ionization of metals presented in relatively smaller particles, greater surface area tends to provide higher ionization exchange in the water and greater pathogen reduction. In certain instances, it is believed that biocidal metals including silver, zinc and copper ionize the water to produce positively charged ions, which then attach themselves to the pathogens such as bacterial cell walls, damaging and deactivating the pathogen. When combined with the inorganic particles 116, the positively charged ions may be adsorbed onto the inorganic particles, creating a cation web matrix 116 to provide additional synergy in the biocidal effects of the water filtration device 100. Moreover, the inorganic particles 114, 116 entrap pathogens, and therefore, negative charges on the pathogens help attract the positively charged biocidal ions onto the inorganic particles 114, 110 upon which positive charged ions are already present. This also improves the synergistic biocidal effects of the water filtration device 100.

[66] In one or more embodiments, it is appreciated; however, the sizes of the metals are to be balanced against the desirable water flow, as finer particle sizes are generally related to slower transport of the water flowing through the metal particles. In addition, it is believed that calcium carbonate helps increase the pH value of the water within and exiting the second filtration container. It is also believed that the calcium ions Ca^{2+}, via their positive charges, are attachable to inorganic particles such as clay particles which are often negatively charged, hence enhancing clarity and reducing turbidity of the discharge water.

[67] In yet another embodiment, the first and second chambers 102, 104 may each independently include a toxic metal absorber selected from the group consisting of an iron oxide, a manganese oxide, aluminum hydroxide, aluminum oxide, bone meal, iron ore, metal fillings, positively charged and negatively charged resins, granular activated carbon or combinations thereof. When employed, the toxic metal absorber may be contained within a detachable sack for easy access and removal. The sack for holding the toxic metal absorber can be of any suitable material that is water permeable and does not facilitate any material leakage of the toxic metal absorber from the sack. The toxic metal absorber can be positioned on top of the first and second pluralities of inorganic particles such that water contacts the toxic metal absorber prior to exiting to the first or second plurality of inorganic particles. To balance between filtration efficacy and material and implementation costs, and in certain instances, the toxic metal absorber may be included in one or both of the first chamber 102 and the second chamber 104. Without wanting to be limited to any particular theory, it is believed that the toxic metal absorber is beneficial in trapping and hence reducing concentrations in water of arsenide, arsenate, and/or fluoride. In certain instances, the iron oxide is selected from the group consisting of FeO, Fe_3O_4, Fe_2O_3, α-Fe_2O_3, β-Fe_2O_3, γ-Fe_2O_3, ε-Fe_2O_3 , ($Fe(OH)_2$), ($Fe(OH)_3$),(α-FeOOH), (β-FeOOH), (γ-FeOOH), (δ-FeOOH), ($Fe_5HO_8 \cdot 4H_2O$), FeOOH, and combinations thereof. In certain other instances, manganese oxide is selected from the group consisting of MnO, Mn_3O_4, Mn_2O_3, MnO_2, Mn_2O_7 and combinations thereof.

[68] In yet another embodiment, and as depicted in Figure 1E, a bio-film zone 118 is disposed on top of the inorganic particles 114. Without being limited to any particular theory, it is believed that beneficial organisms contained within the bio-film help breakdown one or more types of pathogens involved in the raw water. The beneficial organisms may be derived naturally from the raw water or may be added from an external source. In particular instances, the bio-film may include a substrate such as porous ceramic particles to support the beneficial organisms. In the meantime, the inorganic particles may also be provided with certain level of porosity, synergistically providing the aerobic beneficial organisms with a safe place to live and thrive at the water/particle interface in the bio-remediation chamber.

[69] In certain instances, the bio-film zone 118 has a thickness of up to 3.0 inches. In certain particular instances, the bio-film zone 118 has a thickness of 0.1 to 3.0 inches, 0.1 to 2.5 inches, 0.1 to 2.0 inches, 0.1 to 1.5 inches, 0.1 to 1.0 inches, or 0.1 to 0.5 inches.

[70] In one or more embodiments, raw water is introduced into the top of the first chamber 102 and flows down by gravity through the inorganic particles. The raw water first passes through a diffusion plate such as the diffuser 118, which reduces the disruptive force of the input water and large debris, and protects a delicate biological layer. Without wanting to be limited to any particular theory, it is believed that the inorganic particles functions as a physical barrier that traps water-born particles and larger organisms, Protozoa, Helminthes and cysts causing them to accumulate in the uppermost layers of the inorganic particles. Organic material and organisms caught in the uppermost layers of the inorganic particles may eventually develop into a dense population referred to as a biological layer such as the bio-film zone 118.

[71] As the water passes through the bio-film zone 118, microbial contaminants such as parasites, bacteria, viruses, and organic contaminants may be consumed by the beneficial organisms residing in the bio-film zone 118. Protozoa, helminthes, cysts are too large to pass through the first few layers of the inorganic particles and are retained within the bio-film zone 118. As the beneficial organisms require certain moisture to remain viable, sufficient water is provided to the first container 102 such that the bio-film zone 118 is constantly in contact with water at any operational time point. In certain instances, and to ensure sufficient oxygen transfer to maintain the functionality of the beneficial

organism, a thin water layer 120 is constantly maintained above the bio-film zone 118 to keep the beneficial organisms moist and alive.

[72] The inorganic particles 114, 116 may act as a microscopic sedimentation bed for the passing water, helping reduce turbidity, odor, taste, and/or entrapping harmful micro-organisms from the water. The size and shape of the inorganic particles may be varied to tailor the formation of the bio-film zone 118 and hence the effectiveness of the filtration process. By the time the water reaches through the bulk of the inorganic particles such as porous ceramic particles, a significant percentage such as 30 to 60 percent of microbial contaminants have been eliminated by the bio-remediation stage.

[73] In one or more embodiments, the water filtration device may be portable or stationary. The stationary version of the water filtration device may be used for community use, or these devices can be termed community devices. When designed as portable, the water filtration device may have a dimension selected from the group consisting of a longitudinal length of between 15 to 36 inches, a total dry weight of 25 to 200 pounds, a cross-section of 10 to 24 inches in diameter, and combinations thereof. In certain instances, the total dry weight may be 30 to 150 pounds, 35 to 125 pounds, 40 to 85 pounds, 45 to 80 pounds, 50 to 75 pounds, 35 to 45 pounds, 45 to 50 pounds, 50 to 55 pounds, 55 to 60 pounds, 60 to 65 pounds, 65 to 70 pounds, 70 to 75 pounds, 75 to 80 pounds, 80 to 85 pounds, or 85 to 90 pounds. When designed as stationary, the water filtration device may have a dimension selected from the group consisting of a longitudinal length of between 30 to 110 inches, a total dry weight of 120 to 8000 pounds, a cross-section of 20 to 60 inches in diameter, and combinations thereof. In certain instances, the total dry weight of the stationary type of the water filtration device may have a dry total weight of 1,000 to 6,000 pounds, 1,000 to 3,000 pounds, 2,000 to 5,000 pounds, or 2,000 to 6,000 pounds.

[74] The filtered water flows out of the second outlet 108b and may be collected in a safe storage container to prevent post-treatment contamination. Average flow rate of the filtration device 100 may be 4 to 10 liters per hour, enough to provide a family of four with sufficient water for their daily drinking and cooking needs. Assuming an individual

needs 2 liters of water per day to drink, a family of 5 needs 10 liters. The water filtration device 100 can generate 20, 25, 30 liters or more in 5 hours, with the 15 liters for cooking and bathing. Therefore, the water generation capacity of the water filtration devices according to one or more embodiments of the present invention is well suited for that need.

[75] In yet another embodiment, and as depicted in Figure 2, the cross-sectional diameter “D1” of the first chamber 102 is different from, and particularly smaller than, the cross-sectional diameter “D2” of the second chamber 104. Relative to “D2” of Figure 1E, “D2” of this design is extended and represent a wider biocidal chamber for certain particular projects. In this design, the total dry weight of the water filtration device 100 may be 10 to 50 pounds heavier than the water filtration device 100 referenced in Figure 1E.

[76] In certain instances, a volume ratio between the first and second chambers 102, 104 can be 10:1 to 1:10, 8:1 to 1:8, 6:1 to 1:6, 4:1 to 1:4, or 2:1 to 1:2. In certain particular instances, and as depicted in Figure 1E, the volume ratio between the first and second chambers 102, 104 is 1.5:1 to 1:1.5 or 1.1:1 to 1:1.1. In other particular instances, and as depicted in Figure 2, the volume ratio between the first and second chambers 102, 104 is 1:1.5 to 1:2.5 or 1:1.8 to 1:2.2.

[77] The water filtration device 100 of Figure 3 shows a variation to the water filtration device 100 of Figure 1E. In this design, the first chamber 102 is positioned, in its entire height “H1”, above the second chamber 104. Desirable dwell time for the water in the first chamber 102 may be determined according to various parameters, including the height “H1” of the first chamber 102 and the cross-sectional diameter “D1” of the first chamber 102, among others. Prior to the desirable dwell time is reached, a control valve 330, which is accessible from outside of the device 100, stays closed to prevent water flow into the second chamber 104. Similarly, desirable dwell time for the water in the second chamber 104 may also be determined by the height “H2” and cross-sectional diameter “D2” of the second chamber 104. Within the spirit of the water filtration device 100 being employed for “point of use” and with dimensions suitable for portable applications, values “H1”, “H2”, “D1”, and “D2” can suitably vary. For instance, “H1” can be equal to, greater

than, or less than “H2”. “D1” can be equal to, greater than, or less than “D2”. In certain instances, and as depicted in Figure 4, the water filtration device 100 has a wider second chamber 104 than the one of Figure 3.

[78] In yet another embodiment, and as depicted in Figure 5, a water filtration device 100 includes only the biocidal chamber 104, but in a larger version with greater value for “D2”. This device 100 is designed to be charged with water, left overnight with 8 to 12 hour dwell time and discharged into one or more buckets 530 the next morning. Consumers gather water from the buckets 530 and refill the device 100 after the discharge. The refill can be carried out one or more times a day as long as desirable dwell time is achieved to ensure water quality. This device 100 may have a greater total dry weight of 50 to 200 pounds, 75 to 150 pounds, 85 to 125 pounds, 90 to 120 pounds, or 95 to 115 pounds.

[79] In yet another embodiment, and as depicted in Figure 8A, a water filtration device 100a is provided for community use, or alternatively referred to as the “community unit 100a.” As referenced herein elsewhere, the lower portion 804 includes inorganic particles having a relatively greater average particle size relative to the inorganic particles contained within the upper portion 802. The community unit 100a may have any dimension suitable for community use. In certain instances, the community unit 100a has one or more of the following dimensions: a unit width/diameter “W” of 41 to 51, 43 to 49, or 45 to 47 inches, a unit height “H_2” for the upper portion 802 of the biocidal particles of 35 to 41, 36 to 40, or 37 to 39 inches, a unit height “H_1” for the lower portion 804 of the base particles of 3 to 9, 4 to 8, or 5 to 7 inches, and a dry total weight of 1000 to 3000 lbs, 1500 to 2500 lbs, or 1750 to 2250 lbs. A user may retrieve the treated water via a conduit 806 which has a distal end 808 received within the lower portion 804. The conduit 806 may be of any suitable height “L” from the base of the unit 100a. In certain instances, the height “L” is less than 28 inches, 25 inches, 22 inches, or 19 inches. During operation, a layer 810 of water is optionally maintained over the top of the upper portion 802.

[80] In yet another embodiment, and as depicted in Figure 8B, a community unit 100b, as a variation to the community unit 100a of Figure 8A, is provided for consumption

by a community of relatively greater size. In certain instances, the community unit 100b has one or more of the following dimensions: a unit width/diameter "W" of 41 to 51, 43 to 49, or 45 to 47 inches, a unit height "H_2" for the upper portion 802 of the biocidal particles of 83 to 89, 84 to 88, or 85 to 87 inches, a unit height "H_1" for the lower portion 804 of the base particles of 3 to 9, 4 to 8, or 5 to 7 inches, and a dry total weight of 2,000 to 6,000 lbs, 3,000 to 5,000 lbs, or 3,500 to 4,500 lbs.

[81] The water treatment/filtration device according to one or more embodiments of the present invention, such as the device 100 referenced in Figures 1A-1H, 2-3, 7, 9 and device 100a, 100b referenced in Figures 8A, 8B, may be used in connection with a storage unit, such as the storage unit 902 depicted in Figure 9. For illustration purposes, Figure 9 depicts a water treatment/filtration device 900 including a device 100 referenced in Figure 1F detachably coupled to the storage unit 902. Water exiting from the lower portion 146 may flow to the storage unit 902 via a conduit 904. The conduit 904 has a first distal end 906 received within the lower portion 146 and a second distal end 908 received within the storage unit 902. A user may retrieve treated water from the storage unit 902 via a control valve 910. The storage unit 902 may include the same particle and biocide components employed in the first and/or second chambers, however, the amount of the inorganic particles and/or the biocide may vary depending on the water consumption demand. Without wanting to be limited to any particular theory, it is believed that ion exchange with the water provides a residual disinfection of the water within the storage unit and therefore, storing the water in the storage unit after treatment with the first and/or second chamber further reduces certain health risks. Components of the biocide may be confined within a sack with perforations, optionally made of synthetic fabric, such that flowing out of the biocide media may be reduced or event prevented, while the exchange of metal ions for disinfection purposes is largely retained.

[82] With the storage unit, the biocide components may be easily placed and contained within the storage unit. In certain instances, walls or external surfaces of the storage unit can be made of flexible materials such as plastics, water impermeable paper, or any other suitable materials. Without wanting to be limited to any particular theory, it is believed that the storage unit is not necessarily intended to allow the water to pass through but provides, quite consistently, ion exchanges of copper, zinc, and/or silver to the stored water. In certain particular instances, the storage unit may be provided as a detachable unit.

[83] In certain instances, copper concentration in the discharged or stored water is of from 1 ppm (parts per million) to 500 ppb (parts per billion), from 500 ppb to 100 ppb, or from 99 ppb to 10 ppb. Zinc concentration in the discharged or stored water is no greater than 5.0 ppm, no greater than 2.5 ppm, of from 999 ppb to 500 ppb, or of from 499 to 100 ppb.

[84] According to another aspect of the present invention, there is provided a water filtration composition. In one embodiment, the water filtration composition includes a plurality of inorganic particles mixed with at least one of a biocide, a pH modifier, a toxic metal absorber, or combinations thereof, all of these components being described herein above. In certain instances, the water filtration composition includes the non-water dry contents of the second chamber 104 according to one or more embodiments in relation to Figures 1A-1E and 2-5. In another embodiment, the water filtration composition is individually packaged readily for application by an end user. The water filtration composition can be of any suitable packaging sizes. Non-limiting examples of the packaging sizes include 0.5 to 25 pound packages, 25 to 75 pound packages, 75 to 100 pound packages, or 100 to 200 packages, 200 to 1,000, 1500 to 2500 lb packages. The packages can be of any suitable materials, for instances, materials that are stress-resistant, chemical-inert, and/or water proof. Non-limiting packaging materials include synthetic fibers, plastics, polymers, waxed natural fibers, leather, woven poly bulk sacks and combinations thereof.

[85] In yet another embodiment, the water filtration composition may include non-porous inorganic particles supplemented with one or more biocides, pH modifiers, and/or toxic metal absorbers described herein. In certain particular instances, the water filtration composition includes sand as the non-porous inorganic particles and a plurality of silver, copper, and/or zinc rods, flakes, needles, granules, or the like.

[86] The water filtration composition as described herein can be used in conjunction with any existing technologies. For instances, and depicted in Figure 6, the water filtration composition can be purchased by an end user and disposed in a suitable container together forming a water filtration chamber 602. The water filtration chamber 602, along with first and second conduits 106, 108, forms a water filtration add-on kit 600. The water filtration add-on kit can be attached to any existing water treatment unit 650 that consumers might already have in their possession yet with unsatisfactory filtration efficiency. The existing water treatment unit 650 may include fine sand 630. Non-limiting examples of the existing water treatment unit 650 may include those known as slow sand filtration devices, Biosand devices, and the like. The water filtration add-on kit according to one or more embodiments of the present invention provides a cost-effective supplement to these existing community water filtration systems to improve water quality. This is particularly advantageous for those in the developing world where water quality is relatively poor and means for improving the water quality is relatively limited.

[87] According to another aspect of the present invention, there is a method of providing water for drinking, cooking and bathing. In one embodiment, and as depicted in Figure 11, a method is generally shown at 1180. At step 1102, a water filtration device is provide to have a first chamber including a first plurality of inorganic particles, and a second chamber including a second plurality of inorganic particles and being in water communication with the first chamber. At step 1104, raw water is introduced into the first chamber for a first pre-determined dwell time to form a first treated water. At step 1106, the first treated water is allowed to travel into the second chamber for a second pre-determined amount of dwell time to form the second treated water. At step 1108, the second treated water is collected for drinking, cooking, and bathing. Method 1180 represents a water filtration method employing a water filtration device having two or more chambers as described herein elsewhere.

[88] In another embodiment, and as depicted in Figure 11, a method generally shown at 1190 presents a variation to the method 1180. Method 1190 represents a water filtration method employing a water filtration device having a single chamber design as

described herein elsewhere. At step 1112, a water filtration device is provided to have a chamber including a plurality of porous inorganic particles and a biocide. At step 1114, raw water is introduced into the chamber for a pre-determined dwell time to form treated water. At step 1118, the treated water collected for drinking, cooking, and bathing.

[89] In providing additional description to one or more embodiments of the present invention, the following examples are non-limiting.

[90] EXAMPLES

[91] Example 1

[92] A sample water filtration device is constructed according to Figures 1A-1E with parameters specified below. This sample device is 22 inches in height and 14 inches in diameter. The first outlet of the first discharge conduit is 15 inches above the base and the second outlet of the second discharge conduit is 13 inches above the base. Both the first and second chambers include 5x30 porous ceramic particles. The second chamber further includes, as a biocidal agent, silver powder, copper powder, and copper sulfate. In addition, the second chamber also includes, as a pH modifier, calcium carbonate. The entire device is about 53 pounds in total dry weight.

[93] Example 2

[94] A sample water filtration device is constructed according to Figures 1A-1E with parameters specified below. This sample device is 22 inches in height and 14 inches in diameter. The first outlet of the first discharge conduit is 15 inches above the base and the second outlet of the second discharge conduit is 13 inches above the base. Both the first and second chambers include 24 x 48porous ceramic particles with a sublayer, positioned in the areas 144 and 146 or 154 and 158, of ½” x 6 porous ceramic particles to prevent migration and undesired discharge of smaller particles from the unit. The second chamber further includes, as a biocidal agent, silver powder, copper powder, zinc alloy and copper sulfate. In addition, the second chamber also includes, as a pH modifier, calcium carbonate. The entire device is about 60 pounds in total dry weight.

[95] Example 3

[96] A sample water filtration device is constructed substantially according to the one of Example 2, with the exception that no calcium carbonate is included in the device.

[97] Example 4

[98] A sample water filtration device is constructed substantially according to the one of Example 2, with the exception that both chambers each include a biocide and no calcium carbonate is included in the device.

[99] Example 5

[100] A sample water filtration device is constructed according to Figure 2 with parameters specified below. This sample device is 22 inches in height and 17 inches in diameter. The first outlet of the first discharge conduit is 15 inches above the base and the second outlet of the second discharge conduit is 13 inches above the base. Both the first and second chambers include 5x30 porous ceramic particles. The second chamber further includes, as a biocidal agent, silver powder, copper powder, and copper sulfate. In addition, the second chamber also includes, as a pH modifier, calcium bicarbonate. The entire device is about 75 pounds in total dry weight.

[101] Example 6

[102] A sample water filtration device is constructed according to Figure 2 with parameters specified below. This sample device is 22 inches in height and 14 inches in diameter. The first outlet of the first discharge conduit is 15 inches above the base and the second outlet of the second discharge conduit is 13 inches above the base. Both the first and second chambers include 24x48 porous ceramic particles. The second chamber further includes, as a biocidal agent, silver powder, copper powder, zinc alloy and copper sulfate. In addition, the second chamber also includes, as a pH modifier, calcium bicarbonate. The entire device is about 90 pounds in total dry weight.

[103] Example 7

[104] Another sample water filtration device is constructed according to Figure 2 with parameters specified below. This sample device is 22 inches in height and 14 inches in diameter. The first outlet of the first discharge conduit is 15 inches above the base and the second outlet of the second discharge conduit is 13 inches above the base. Both the first and second chambers include 24 x 48 porous ceramic particles with a sub-layer at the base of each chamber of ½” x 6 porous ceramic particles to prevent migration and discharge of particles from the device. The second chamber further includes, as a biocidal agent, silver powder, copper powder, Zinc alloyand copper sulfate. In addition, the second chamber also includes calcium bicarbonate as a pH modifier and other agents including iron oxide, manganese oxide, bone meal, iron ore, metal fillings, positive and negatively charged resin, aluminum hydroxide, aluminum oxide and combinations thereof.

[105] Example 8

[106] Another sample water filtration device is constructed substantially according to the one of Example 7, with the exception that the sample device has a diameter of 14 inches.

[107] Example 9

[108] Another sample water filtration device is constructed according to Figure 5 with parameters specified below. This sample device is 22 inches in height and 18 inches in diameter. The second and the only chamber includes 24 x 48 porous ceramic particles. The second chamber further includes, as a biocidal agent, silver powder, copper powder, zinc alloy and copper sulfate. In addition, the second chamber also includes calcium bicarbonate as a pH modifier. The device is about 100 pounds in total dry weight.

[109] Example 10

[110] Another sample water filtration device is constructed according to Figure 5 with parameters specified below. This sample device is 22 inches in height and 18inches in diameter. The second and the only chambers include 24 x 48 porous ceramic particles. The second chamber further includes, as a biocidal agent, silver powder, copper powder, zinc alloy and copper sulfate. In addition, the second chamber also includes calcium bicarbonate as a pH modifier, agents including iron oxide, manganese oxide, bone meal, iron ore, metal fillings, positive and negatively charged resin, and combinations thereof. The device is about 100 pounds in total dry weight.

[111] Examples 11 and 12

[112] In one or more embodiments, and particularly in Examples 11 and 12, test protocols for various water analysis methods may be as follows. Relevant provisions from Standard Methods (SM) for determining total coliform counts may include SM9222B and SM9223B; for determining total *E. Coli* counts may include SM9221F and SM9223B; for determining total fecal coliform counts may include SM9222D; for determining heterotrophic bacterial counts may include SM9215B; for determining water turbidity may include SM2130B and/or EPA 180.1, wherein EPA stands for United States Environmental Protection Agency; for determining pH values may include SM4500H-B; for determining viruses may include SM1601 and SM1602; for determining protozoa may include ASTM-D5916-96 (2002).

[113] Example 11

[114] Another sample water filtration device is constructed according to the design of Figure 1E. The first and the second containers include 5x30 porous ceramic particles. The second container includes 25 grams of ground silver, 50 grams of ground copper, suitable amount of copper sulfate, and 2000 grams of sand sized calcium carbonate. Two test methods are employed for this sample device. Total coliform and *E. Coli* coliform are measured using multiple tube fermentation (MTF) method with lauryl trytose broth and coliform ferment lactose to produce acid and gas within 48 hours at 35 degrees Celsius. Fecal coliform is measured and plated on membrane filtration method (MFM) where organisms are grown in petri dish and counted on a grid. Fecal coliform reduction efficiency is analyzed using this sample device. Ten (10) individual tests, each

using a different batch of raw water, are each run on a separate day with test results tabulated in Table 3a shown below.

[115] Table 3a

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Fecal Coliform Reduction Efficiency	100%	100%	100%	98%	98%	100%	100%	99%	100%	98%
Fecal Coliform Initial Counts	125	1525	1300	1600	293	960	855	605	3290	1826

[116] *E. Coli* coliform reduction efficiency is also analyzed on each of the same water specimens referenced in Table 3a and results are tabulated in Table 3b shown below.

[117] Table 3b

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
E. Coli Coliform Reduction Efficiency	100%	100%	99%	99%	97%	100%	99%	99%	100%	97%
E. Coli Coliform Initial Counts	60	600	625	900	98	319	328	250	900	1826

[118] Total fecal coliform reduction efficiency is also analyzed on each of the same water specimens referenced in Table 3a and results are tabulated in Table 3c shown below.

[119] Table 3c

Test #	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Total Coliform Reduction Efficiency	100%	100%	99%	97%	97%	100%	99%	98%	99%	95%
Total Coliform Initial Counts	313	1600	1425	1600	330	770	1038	517	1600	1600

[120] Turbidity reduction is also analyzed on each of the same water specimens referenced in Table 3a and results are tabulated in Table 3d shown below. Turbidity reduction is analyzed using this sample device. As referenced herein, the term "NTU" refers to "Nephelometric Turbidity Units" which represent light refraction of the water samples. The higher the NTU value, the cloudier and less healthy the water sample. Based on this analysis, NTU value of no greater than 5 NTUs is acceptable for drinking and cooking water uses. As can be seen from the filtration results shown in Table 3d, average NTU output values for each of the days in the analysis are well within the recommended guideline of 5 NTUs or lower according to the World Health Organization.

[121] Table 3d

Test #	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Average NTU Input	6	15	12	21	13	8	13	10	13	7
Average NTU Output	1323	1.3	2.2	3.1	3.0	2.3	2.9	3.0	3.7	2.2
Reduction Efficiency	232x	91%	81%	85%	78%	70%	78%	70%	71%	70%

[122] This sample device is also evaluated for *E. Coli* reduction efficiency based on running time. A container full of raw water is placed in the sample device for a dwell period of 12-16 hours. Water output is taken 1 hour, 3 hours, and 5 hours after the completion of the dwell period and the addition of untreated raw water to keep the container full at any time point. Addition of untreated raw water causes the device to discharge treated water, as the internal volume of the device is generally kept constant. The evaluation is repeated and corresponding *E. Coli* reduction efficiency is recorded in Table 6e shown below. As can be seen from Table 6e, 100% *E. Coli* reduction is observed with water taken 1 hour after the 12- to 16-hour dwell period and represent the water that has been treated with the maximum benefit of the dwell time. Untreated water introduced into the first chamber pushes water out of the second chamber. Water samples are also taken at 3-hour and 5-hour time points with an effort to evaluate water qualities of these discharged water portions. These later time points are important to examine as the corresponding water portions may involve portions of water that have had less than the original dwell time of 12 to 16 hours. As can be seen from Table 3e, this sample device is able to produce filtered water with acceptable quality in *E. Coli* reduction.

[123] Values for water taken 3 hours or 5 hours after the initial 12- to 16-hour dwell period show minor degree of decrease in *E. Coli* reduction efficiency, yet are still well within the safe drinking water guidelines as prescribed by the WHO. Without wanting to be limited to any particular theory, it is believed that the decrease in *E. Coli* reduction efficiency at 3-hour and 5-hour time marks is attributable to the fact that the bulk of the water in the filtration device at these time marks is a mixture of water having relatively higher and relatively lower dwell time.

[124] Table 3e

Test #	1st	2nd
1 hour after	100%	100%
3 hours after	100%	99%
5 hours after	100%	99%
E. Coli Coliform Initial Count	60	328

[125] Example 12

[126] A sample water filtration device is constructed according to the design of Figure 1E. The first and the second containers include 5X30 porous ceramic particles. The second container includes 25 grams of ground silver, 250 grams of ground copper, suitable amount of copper sulfate, and 4000 grams of sand sized calcium carbonate. Fecal coliform reduction efficiency is analyzed using this sample device. Twelve (12) individual tests are each run on a separate day with test results tabulated in Table 4a shown below.

[127] Table 4a

Test #	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Fecal Coliform Reduction Efficiency	100 %	100 %	98%	100 %	99%	100 %	100 %	100 %	100 %	99%	100 %	100 %
Fecal Coliform Initial Counts	600	992	1275	679	1900	657	3175	850	1685	718	428	1050

[128] *E. Coli* coliform reduction efficiency is also analyzed on each of the same water specimens referenced in Table 4a and results are tabulated in Table 4b shown below.

[129] Table 4b

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
E. Coli Coliform Reduction Efficiency	100 %	100 %	99%	99%	99%	99%	100 %	100 %	100 %	99%	100 %	100 %
E. Coli Coliform Initial Counts	220	325	700	293	767	470	1725	350	722	260	238	663

[130] Total coliform reduction efficiency is also analyzed on each of the same water specimens referenced in Table 4a and results are tabulated in Table 4c shown below.

[131] Table 4c

Test #	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Total Coliform Reduction Efficiency	100 %	100 %	97%	99%	99%	99%	100 %	100 %	100 %	99%	100 %	99%
Total Coliform Initial Counts	900	737	1600	687	1600	1075	3675	1275	2525	1080	1413	1500

[132] Turbidity reduction is also analyzed on each of the same water specimens referenced in Table 4a and results are tabulated in Table 4d shown below. As can be seen from the filtration results shown in Table 4d, average NTU output values for each of the days in the analysis are well within the recommended guideline of 5 NTUs or lower according to the World Health Organization.

[133] Table 4d

Test #	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Average NTU Input	5.2	5.5	5.7	6.1	27.8	6.8	4.7	6.9	5.5	5.8	5.5	6.4
Average NTU Output	139	1	0.8	0.5	2.4	1.2	0.7	1.1	1.9	0.8	1.0	1.2
Reduction Efficiency	26.7x	83%	87%	91%	91%	82%	86%	85%	67%	86%	83%	81%

[134] This sample device is also evaluated for *E. Coli* reduction efficiency based on running time. A container full of raw water is placed in the sample device for a dwell period of 12 to 16 hours. Water output is taken 1 hour, 3 hours, and 5 hours after the completion of the dwell period and the addition of untreated raw water to keep the container full at any time point.

[135] The evaluation is repeated on a different day and corresponding *E. Coli* reduction efficiency is recorded in Table 4e shown below. As can be seen from Table 4e, 100% *E. Coli* reduction is observed with water taken 1 hour after the 12- to 16-hour dwell period and represent the water that has been treated with the maximum benefit of the dwell time. Values for water taken 3 hours or 5 hours after the initial 24-hour dwell period show no substantial degree of decrease in *E. Coli* reduction efficiency.

[136] Table 4e

Test #	1st	2nd
1 hour after	99.8%	100.0%
3 hours after	99.6%	99.7%
5 hours after	99.8%	99.4%
E. Coli Coliform Initial Count	1725	722

[137] Example 13

[138] Two chambers, both combining biocide with porous ceramic particles – this is applicable to each of the following charts and sections. Each chamber contains a layer at the base of ½" x 6, balance of chamber contains a mixture of 24 x 48 porous ceramic particles and the following biocide components in 798 grams of copper, 100 grams of zinc, 7.5 grams of silver, 2.5 grams of copper sulfate.

[139] Table 5a

	Day 1	Day 2	Day 3	Day 10	Day 11	Day 14	Day 15	Day 16	Day 18
Total Coliform reduction efficiency	100%	100%	99.5%	99.4%	100%	100%	100%	100%	100%
Total Coliform Initial Counts	1400	800	700	840	700	1000	800	2000	700

[140] Table 5b

	Day 1	Day 2	Day 3	Day 10	Day 11	Day 14	Day 15	Day 16	Day 18
E.Coli reduction efficiency	100%	100%	99.8%	100%	100%	100%	100%	100%	100%
E. Coli Initial Counts	600	300	1500	420	300	500	350	1400	320

[141] Table 5c

	Day 1	Day 2	Day 3	Day 10	Day 11	Day 14	Day 15	Day 16	Day 18
Fecal Coliform reduction efficiency	100%	100%	99.92 %	100%	100%	100%	100%	100%	100%
Fecal Coliform Initial Counts	900	500	2400	740	500	800	600	1800	480

[142] Example 14

[143] Two chambers, both combining biocide with porous ceramic particles – this is applicable to each of the following charts and sections. Each chamber contains a layer at the base of ½” x 6, balance of chamber contains a mixture of 24 x 48 porous ceramic particles. Both chambers each include the following biocide components in 798 grams of copper, 100 grams of zinc, 7.5 grams of silver, and 2.5 grams of copper sulfate. Efficiency is reported after 20 liters of water is processed through the device. Without wanting to be limited to any particular theory, this example supports the so-called Cation Web Matrix

Theory as described herein, wherein, as shown here, the device becomes much more effective over time, 60 days after testing its 100% effective after 20 liters on all three water testing indicator bacteria.

[144] Table 6a

	Day 1	Day 7	Day 10	Day 16	Day 24	Day 31	Day 40	Day 50	Day 59
Total Coliform reduction efficiency	99.6%	99.7%	100%	99.6%	98.9%	99.4%	99.6%	100%	100%
Total Coliform Initial Counts	1400	1200	840	2000	1400	800	900	1200	2400

[145] Table 6b

	Day 1	Day 7	Day 10	Day 16	Day 24	Day 31	Day 40	Day 50	Day 59
E.Coli reduction efficiency	99.7%	99.7%	100%	100%	100%	100%	100%	100%	100%
E. Coli Initial Counts	600	700	420	1400	700	210	320	700	1300

[146] Table 6c

	Day 1	Day 7	Day 10	Day 16	Day 24	Day 31	Day 40	Day 50	Day 59
Fecal Coliform reduction efficiency	99.8%	99.8%	100%	100%	100%	100%	100%	100%	100%
Fecal Coliform Initial Counts	900	900	740	1800	1200	360	680	1000	2000

[147] While the best mode for carrying out the invention has been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

WHAT IS CLAIMED IS:

1. A water filtration device comprising:
a first chamber including a first plurality of inorganic particles; and
a second chamber in communication with the first chamber.

2. The water filtration device of claim 1, wherein the second chamber further includes a second plurality of inorganic particles.

3. The water filtration device of claim 1, further comprising a first discharge conduit including a first inlet and a first outlet, wherein, wherein water is present, water is transported through the first chamber via the first inlet to the second chamber via the first outlet.

4. The water filtration device of claim 3, wherein the first outlet of the first discharge conduit is positioned above a first base of the first chamber with a first distance such that water in the first chamber has a first pre-determined dwell time prior to exiting through the first outlet.

5. The water filtration device of claim 3, further comprising a second discharge conduit including a second inlet and a second outlet, wherein water is transported through the second chamber via the second inlet and exits the second discharge conduit via the second outlet.

6. The water filtration device of claim 5, wherein the second outlet of the second discharge conduit is positioned lower than the first outlet of the first discharge conduit with a conduit distance, and wherein second outlet of the second discharge conduit is positioned higher than a second base of the second chamber with a second distance such that water in the second chamber has a second predetermined dwell time prior to exiting through the second outlet.

7. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles are each independently selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatiousearthzeolite, and combinations thereof.

8. The water filtration device of claim 7, further comprising sand.

9. The water filtration device of claim 1, wherein one or both of the first and second chambers further include a biocide, a toxic metal absorber, and/or a pH modifier.

10. The water filtration device of claim 9, wherein one or both of the first and second chambers include the toxic metal absorber disposed within a detachable sack.

11. The water filtration device of claim 9, wherein one or both of the first and second chambers include the toxic metal absorber positioned on top of the first or second pluralities of inorganic particles, respectively, such that water contacts the toxic metal absorber prior to exiting to the first or second plurality of inorganic particles.

12. The water filtration of device of claim 11, wherein the toxic metal absorber is positioned in a layer of 1 to 5 inches in thickness.

13. The water filtration device of claim 9, wherein the first and second chamber each include a biocide, the biocide including one or more of zinc, silver and copper.

14. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles each independently pass no less than 95 percent through a number #5 sieve and are retained no less than 95 percent on a number #30 sieve.

15. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles each independently pass no less than 95 percent through a number #10 sieve and retain no less than 95 percent on a number #20 sieve.

16. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles each independently pass no less than 95 percent through a number #24 sieve and are retained no less than 95 percent on a number #48 sieve.

17. The water filtration device of claim 2, wherein the first and second pluralities of inorganic particles each independently form an upper volume of inorganic particles and a lower volume of inorganic particles having an average particle size greater than an average particle size of the upper volume of inorganic particles.

18. The water filtration device of claim 17, wherein the lower volume of inorganic particles pass no less than 95 percent through a 0.5 inch sieve and are retained no less than 95 percent on a number #6 sieve.

19. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles are each independently of one or more shapes selected from the group consisting of granules, powders, flakes, rods, chunks, cubes, balls, cubes, columns, and combinations thereof.

20. The water filtration device of claim 1 having a dimension selected from the group consisting of a height of 15 to 36 inches, a total dry weight of 25 to 200 pounds, a cross-section of 10 to 24 inches in diameter, and combinations thereof.

21. The water filtration device of claim 1 having a dimension selected from the group consisting of a height of 30 to 110 inches, a total dry weight of 120 to 8000 pounds, a cross-section of 20 to 60 inches in diameter, and combinations thereof.

22. The water filtration device of claim 2, further comprising a third chamber in communication with the second chamber, the third chamber including a third plurality of inorganic particles.

23. The water filtration device of claim 4, wherein the first inlet of the first discharge conduit has an end opening directed towards the first base of the first chamber.

24. The water filtration device of claim 6, wherein the second inlet of the second discharge conduit has an end opening directed towards the second base of the second chamber.

25. The water filtration device of claim 18, wherein one or both of the first and second chambers further include a water-permeable separating layer positioned between the upper and lower volumes of inorganic particles.

26. The water filtration device of claim 5, wherein at least a portion of the first and/or second discharge conduits has an interior cross-sectional diameter of 0.125 to 0.75 inches.

27. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles each independently have a cation exchange capacity of 1 to 200 milli-equivalent per 100 grams.

28. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles each independently have a total porosity of 50 to 90 volume percent, a total capillary porosity of 25 – 60 volume percent, and/or a total non-capillary porosity of 20 – 50 volume percent.

29. The water filtration device of claim 2, wherein at least a portion of the first and second pluralities of inorganic particles have a density of 0.3 to 2.0 grams of dry weight per cubic centimeter.

30. The water filtration device of claim 1, further comprising a storage unit positioned to receive treated water from the first chamber.

31. The water filtration device of claim 1, wherein one or both of the first and second chambers further include a filter, such that water contacts the filter prior to exiting to the first plurality of inorganic particles.

32. A water filtration device comprising:

a first chamber including a first plurality of inorganic particles;

a second chamber including a second plurality of inorganic particles and being in communication with the first chamber;

a first discharge conduit including a first inlet and a first outlet, wherein water is transported from the first chamber via the first inlet to the second chamber via the first outlet, and wherein the first outlet of the first discharge conduit is positioned such that water in the first chamber has a first pre-determined dwell time prior to exiting through the first outlet;

a second discharge conduit including a second inlet and a second outlet, wherein water is transported from the second chamber via the second inlet and exits the second discharge conduit via the second outlet, and wherein the second outlet of the second discharge conduit is positioned such that water in the second chamber has a second-predetermined dwell time prior to exiting through the second outlet, and wherein the second outlet is positioned lower than the first outlet; and

a detachable storage unit positioned to receive water from the second chamber.

33. The water filtration device of claim 32, wherein the first and second pluralities of inorganic particles are each independently selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatiousearthzeolite, and combinations thereof.

34. The water filtration device of claim 33, wherein one or more of the first and second pluralities of inorganic particles further include sand.

35. The water filtration device of claim 32, wherein one or more of the first and second chambers further include a biocide, a toxic metal absorber, and/or a pH modifier.

36. The water filtration device of claim 32, wherein one or more of the first chamber, the second chamber, and the detachable storage unit include the toxic metal absorber disposed within a detachable sack.

37. The water filtration device of claim 35, wherein the first and second chamber each includes a biocide, the biocide including one or more of zinc, silver and copper.

38. The water filtration device of claim 30 having a dimension selected from the group consisting of a height of 15 to 36 inches, a total dry weight of 25 to 200 pounds, a cross-section of 10 to 24 inches in diameter, and combinations thereof.

39. The water filtration device of claim 30 having a dimension selected from the group consisting of a height of 30 to 110 inches, a total dry weight of 120 to 8000 pounds, a cross-section of 20 to 60 inches in diameter, and combinations thereof.

40. A water filtration device comprising:

a chamber having an inlet and an outlet together defining a water treatment volume, the chamber including a biocide and a plurality of inorganic particles disposed within the water treatment volume, the plurality of inorganic particles being selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatious earth zeolite, and combinations thereof.

41. The water filtration device of claim 40, wherein the plurality of inorganic particles include porous ceramic particles.

42. The water filtration device of claim 40, wherein the chamber further includes sand.

43. The water filtration device of claim 40, wherein the biocide includes one or more of silver, zinc and copper.

44. The water filtration device of claim 40 having a dimension selected from the group consisting of a height of 15 to 36 inches, a total dry weight of 25 to 200 pounds, a cross-section of 10 to 24 inches in diameter, and combinations thereof.

45. The water filtration device of claim 40 having a dimension selected from the group consisting of a height of 30 to 110 inches, a total dry weight of 120 to 8000 pounds, a cross-section of 20 to 60 inches in diameter, and combinations thereof.

46. The water filtration device of claim 40, further comprising a filter such that water contacts the filter prior to exiting to the plurality of inorganic particles.

47. The water filtration device of claim 40, further comprising a detachable storage unit positioned to receive treated water from the chamber.

48. A water filtration package comprising:

a water filtration composition including:

a plurality of inorganic particles selected from the group consisting of porous ceramic particles, smectite clay, perlite, vermiculite, zeolite, Fuller's earth, diatomatious earth zeolite, and combinations thereof; and

a filtration supplement including a biocide and/or a toxic metal absorber.

49. The water filtration package of claim 48, wherein the filtration supplement includes the toxic metal absorber disposed within a detachable sack.

50. The water filtration package of claim 48, further comprising a container enclosing the water filtration composition to form the water filtration package.

51. The water filtration package of claim 48, wherein the inorganic particles include porous ceramic particles.

52. The water filtration composition of claim 48, wherein the water filtration composition further includes sand.

53. The water filtration composition of claim 48, wherein the biocide includes one or more of zinc, copper and silver.

54. A method of providing drinking and/or cooking water, comprising:

communicating raw water to a water filtration device of claim 1 or claim 37 to obtain the drinking and/or cooking water.

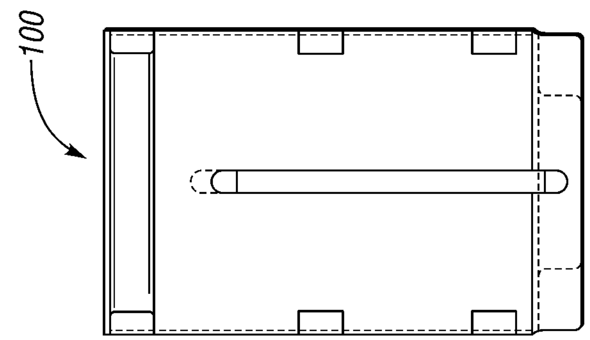

Fig. 1C

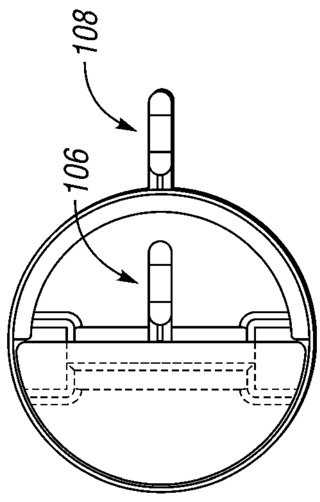

Fig. 1D

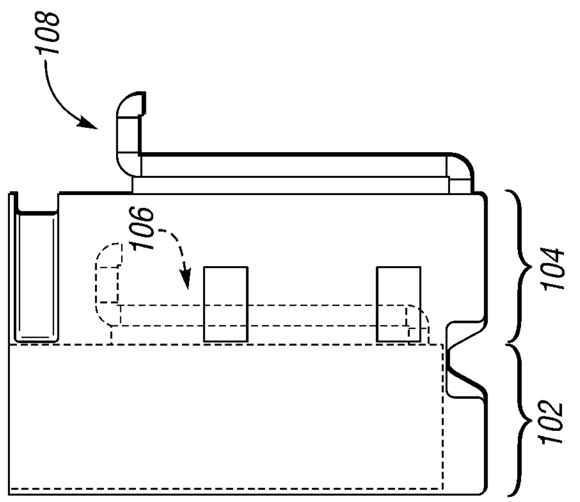

Fig. 1B

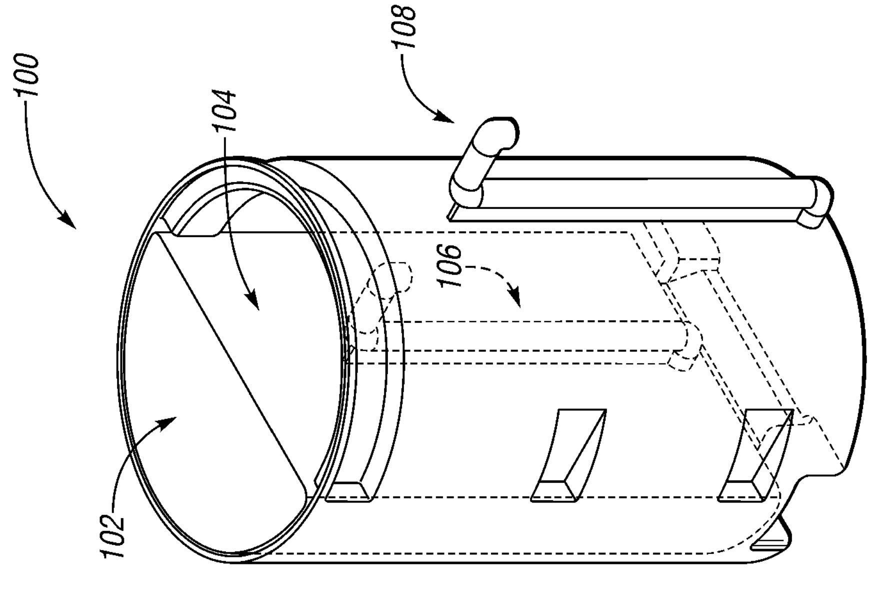

Fig. 1A

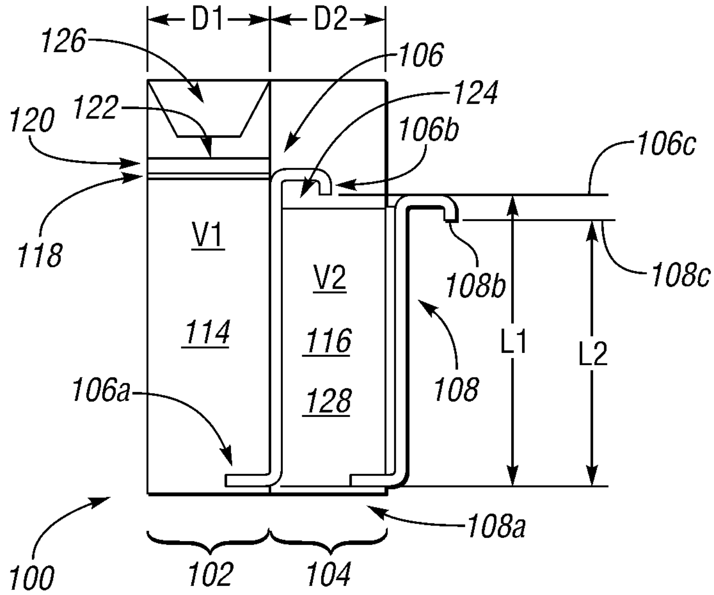

Fig. 1E

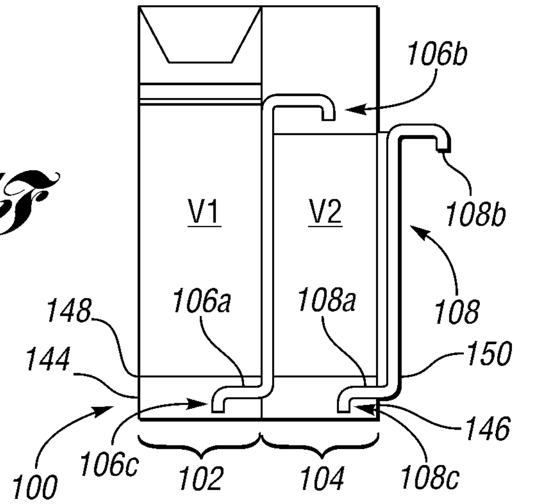

Fig. 1F

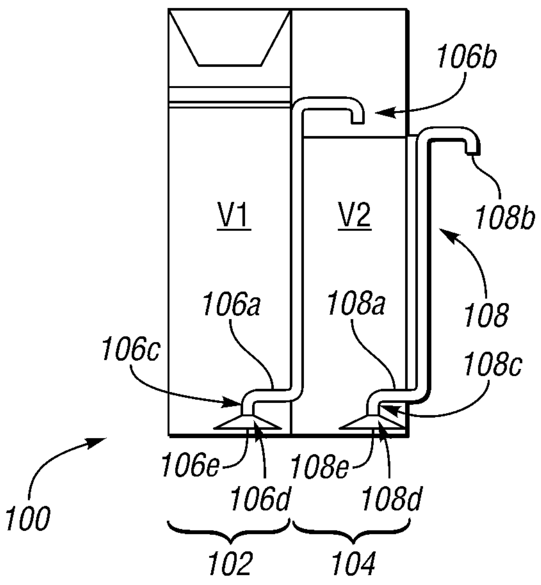

Fig. 1G

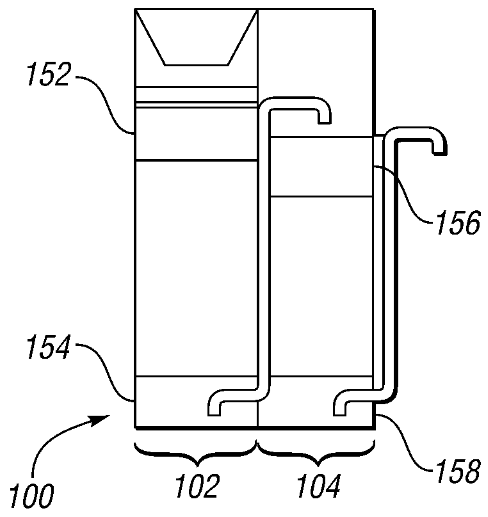

Fig. 1H

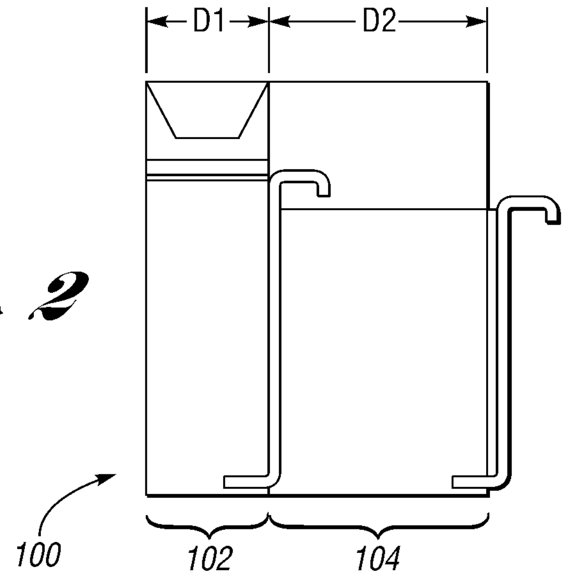

Fig. 2

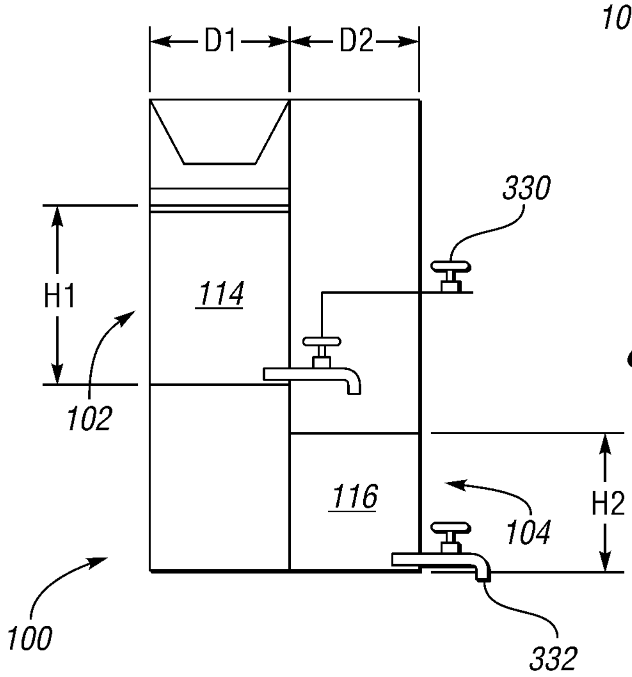

Fig. 3

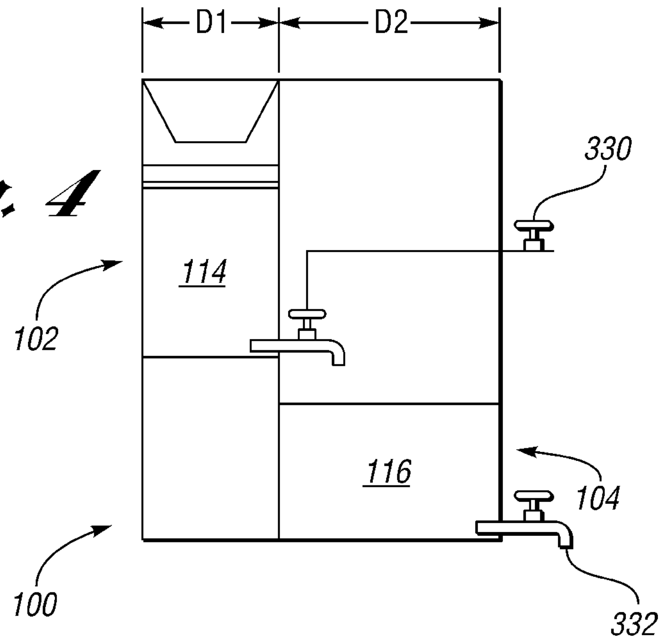

Fig. 4

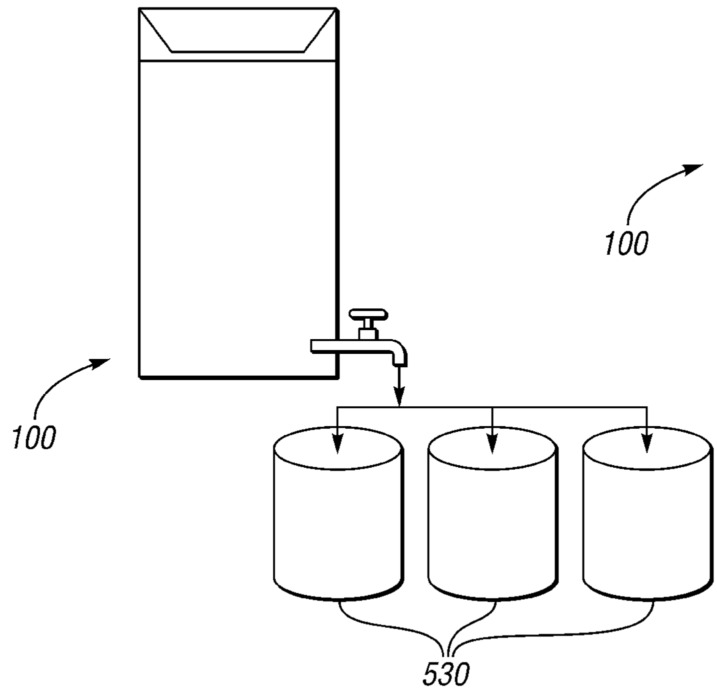

Fig. 5

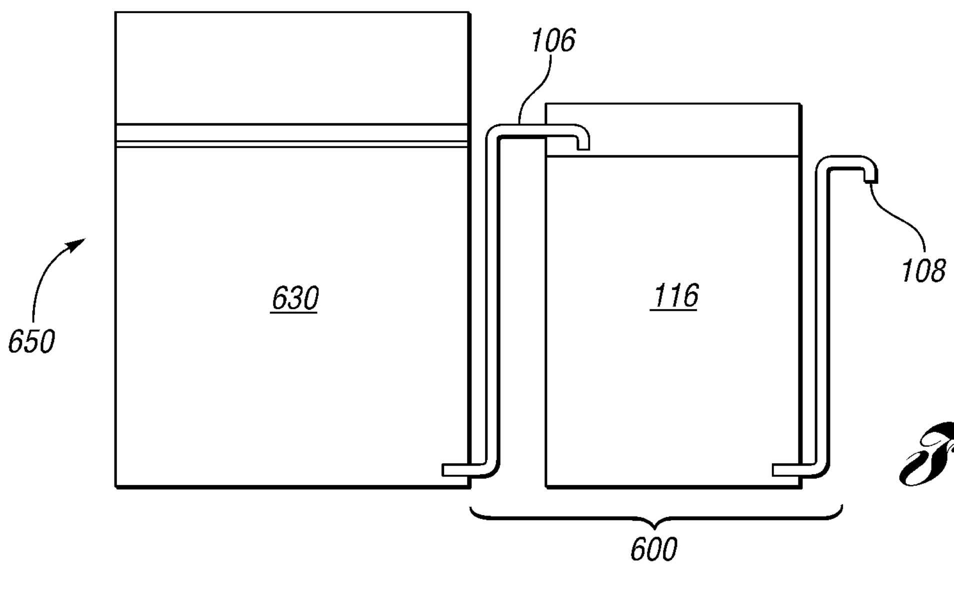

Fig. 6

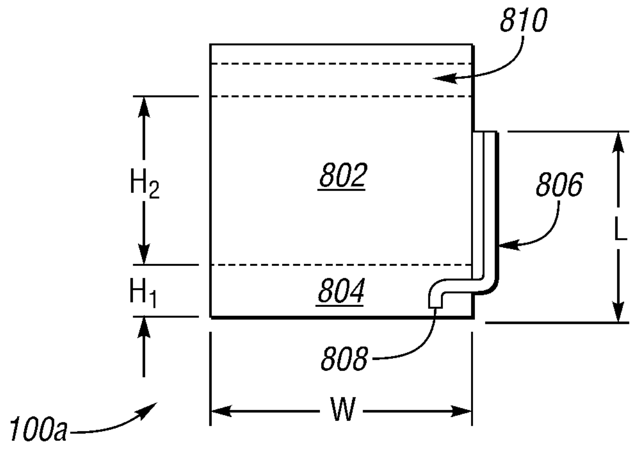

Fig. 8A

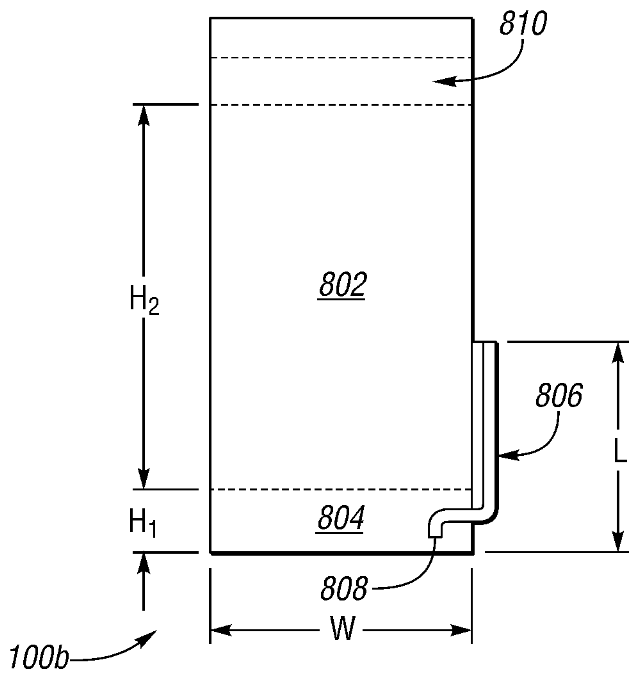

Fig. 8B

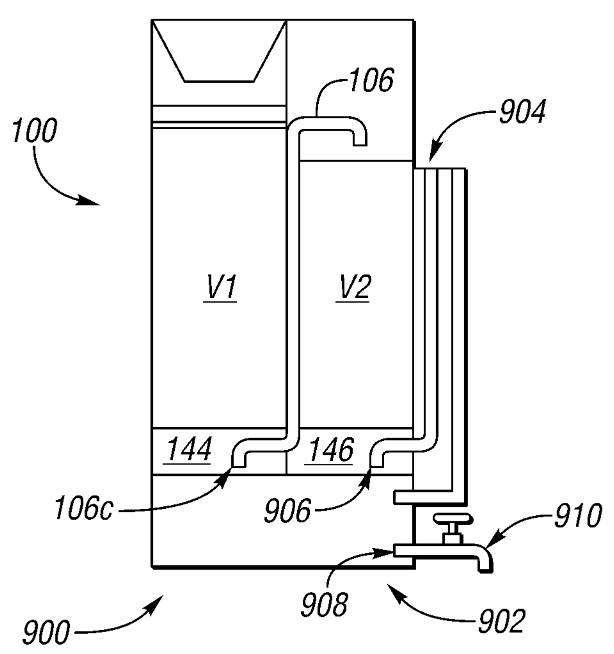

Fig. 9

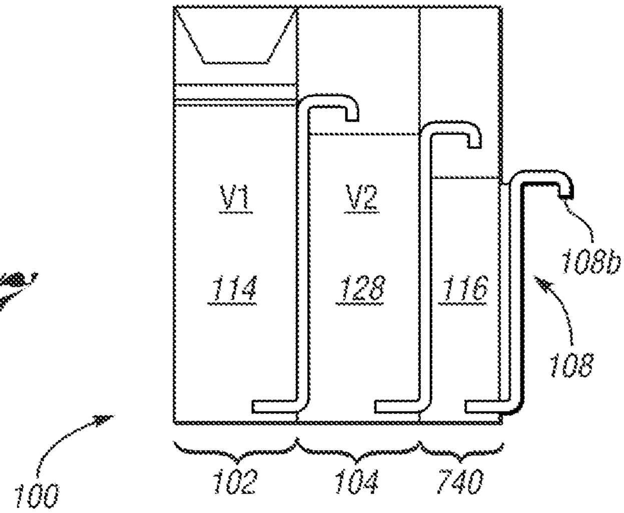

Fig. 7

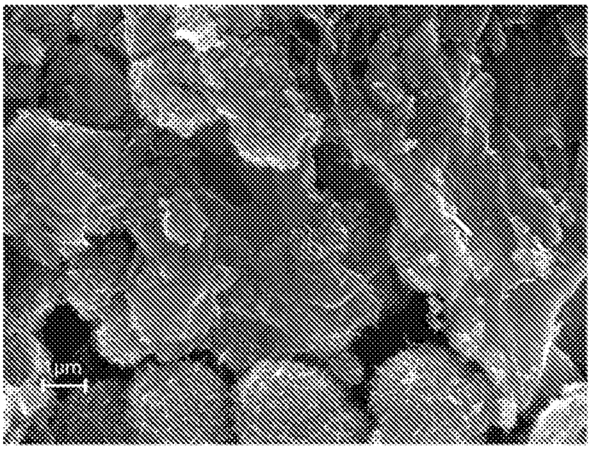

Fig. 10A

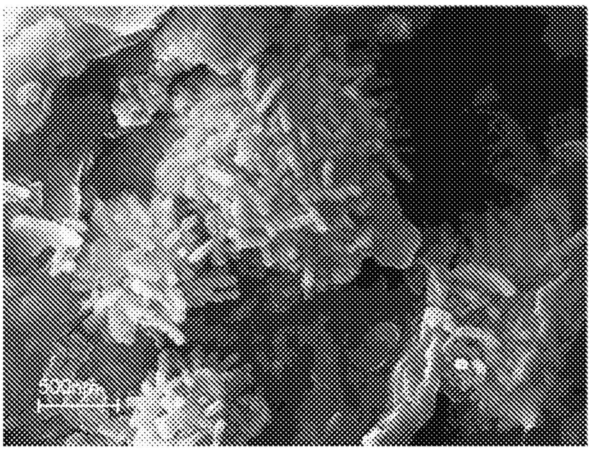

Fig. 10B

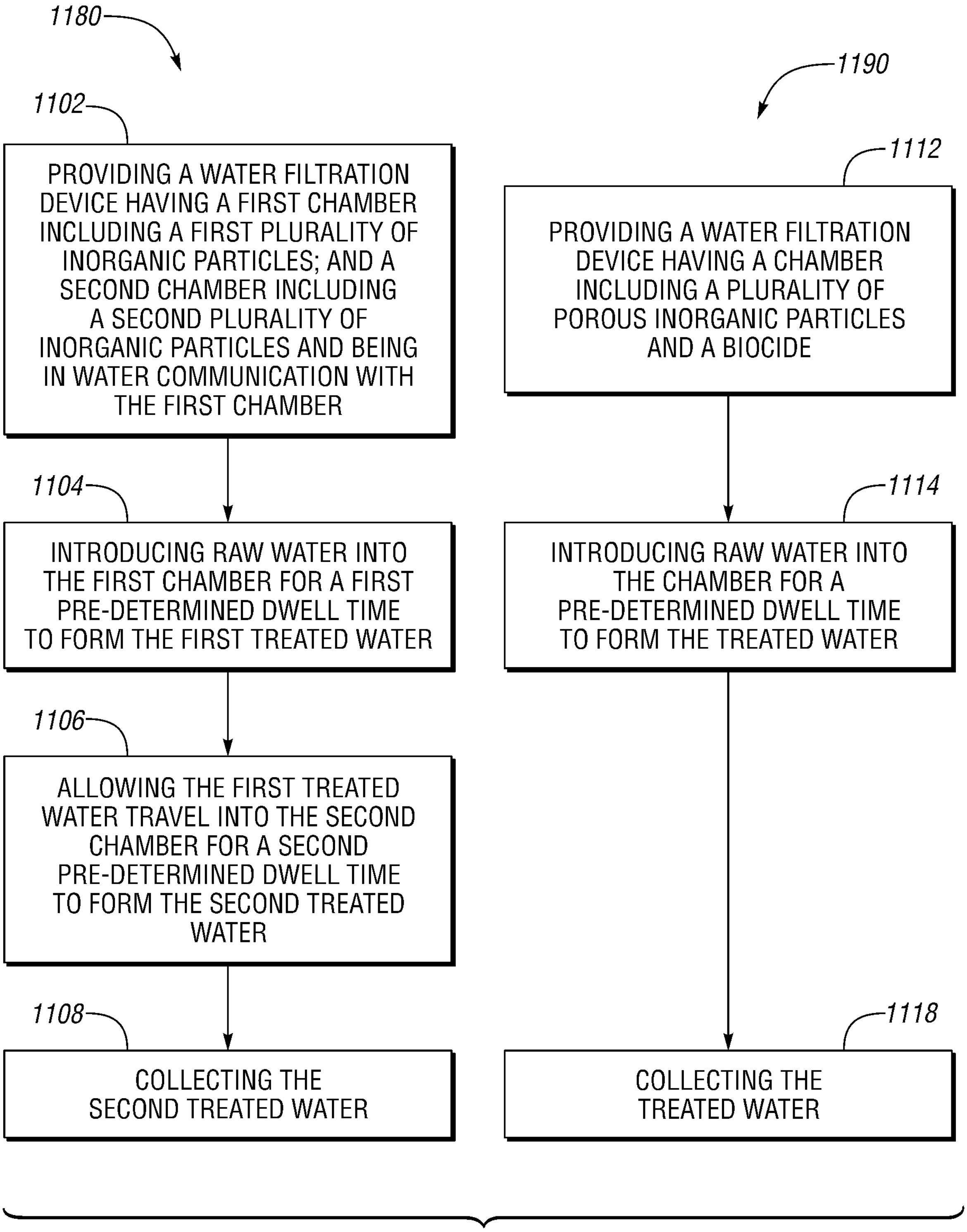
1180
1102
PROVIDING A WATER FILTRATION DEVICE HAVING A FIRST CHAMBER INCLUDING A FIRST PLURALITY OF INORGANIC PARTICLES; AND A SECOND CHAMBER INCLUDING A SECOND PLURALITY OF INORGANIC PARTICLES AND BEING IN WATER COMMUNICATION WITH THE FIRST CHAMBER
1104
INTRODUCING RAW WATER INTO THE FIRST CHAMBER FOR A FIRST PRE-DETERMINED DWELL TIME TO FORM THE FIRST TREATED WATER
1106
ALLOWING THE FIRST TREATED WATER TRAVEL INTO THE SECOND CHAMBER FOR A SECOND PRE-DETERMINED DWELL TIME TO FORM THE SECOND TREATED WATER
1108
COLLECTING THE SECOND TREATED WATER
1190
1112
PROVIDING A WATER FILTRATION DEVICE HAVING A CHAMBER INCLUDING A PLURALITY OF POROUS INORGANIC PARTICLES AND A BIOCIDE
1114
INTRODUCING RAW WATER INTO THE CHAMBER FOR A PRE-DETERMINED DWELL TIME TO FORM THE TREATED WATER
1118
COLLECTING THE TREATED WATER

Fig. 11