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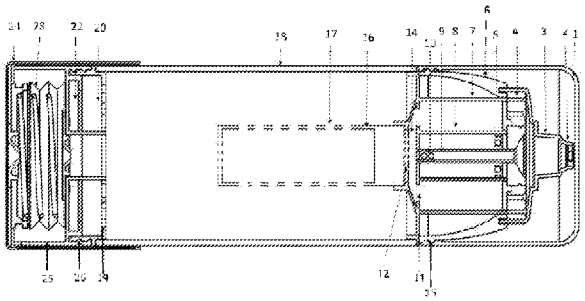
(54) **Title:** A PORTABLE WATER FILTRATION DEVICE FOR REMOVING IMPURITIES FROM WATER USING CONTAMINANT-SPECIFIC PURIFICATION CARTRIDGES



(57) **Abstract:** The present invention relates to a portable water filtration system with region-specific impurity removal capabilities. More specifically relates to a device for removing impurities from water using contaminant-specific purification cartridges. The water filtration device consists of four major assemblies: 1) A re-usable and washable pre-filter [20] for removal of particulate, suspended, and macroscopic impurities, 2) Hollow fiber and electrospun fiber membrane module [16] for microfiltration and ultra-filtration, having pore size of less than or equal to 10 nanometers, to remove microbial contamination, 3) A compact modular annular housing filtration unit [30] with region-specific contaminant removing nano-composite materials housing [7] and activated biocidal charcoal, preferably nanomaterials decorated activated coconut charcoal housing [8] for biocidal activity and organic contaminant removal, and 4) A bellow pump unit [23] to develop pressure inside the feed water container reservoir [18].

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DESCRIPTION

TITLE OF THE INVENTION

A PORTABLE WATER FILTRATION DEVICE FOR REMOVING IMPURITIES FROM WATER USING CONTAMINANT-SPECIFIC PURIFICATION CARTRIDGES

FIELD OF THE INVENTION

The present invention relates to a device for removing impurities from water using contaminants-specific purification cartridges. The present invention also relates to in-situ aeration supported purification of feed water.

BACKGROUND OF THE INVENTION

Affordable point of use personal water purifier is one of the essential requirements of human survival in potable water-scarce regions of the world. In areas where clean water is inaccessible, it is necessary to make any source of water potable. During all natural calamities, the most affected people are the poor and hence an affordable solution is essential for alleviating their suffering. In regions such as West-Bengal and Assam where flood water can also contain regional contaminants, rapid removal of particulate microbial, chemical, and regional contaminants such as arsenic, iron, uranium and fluoride, etc., require a design-supported device with combination of technologies for effective delivery of clean water at acceptable cost and output flow rates. Regional contaminants arise largely due to the geochemistry of the region.

A personal water purifier that can deliver one liter of clean water from region-specific contaminated water requires materials with enhanced removal kinetics, with high adsorption capacity so that the filter is effective during its operational lifetime. This is currently possible only with advanced nano-materials in conjunction with nanofiltration and reverse osmosis.

Products with similar objectives are available, however due to the lack of efficiency of purification materials, membranes, and designs; there has been no effective solution.

PCT application No WO2008037969 describes a device that features membrane and charcoal based filtration. The device is operated with a piston pump to generate pressure in the device. This device doesn't have contaminant-specific water filter medium to address region-specific water contamination problem. Additionally, this device comes with only a hollow fiber

membrane which can only provide biological contaminant-free water. Additionally, the charcoal cartridge gets exhausted as its capacity is limited.

Further, the US Publication No 20120325735 describes a device with biocidal agent that is loaded with nano-fibrous membrane, appropriate resin, and one more suitable adsorbent. This device is capable of killing bacterial contaminant and adsorption of other contaminants but lacks pressure development mechanism which is required for filtration through membrane and a cartridge composed of adsorption media. In the absence of the pump, output flow rate will reduce drastically once the device is in use, making the device unusable.

WO2015040599 describes a portable water filtration device which pushes an empty container consisting of a membrane beneath it, onto another container fed with contaminated water. Since this device uses only one stage, it does not assure filtration of all the available feed water contaminants in the feed water to achieve pure potable water.

From the above prior arts, it can be concluded that all the aforementioned devices do not claim the production of potable water that can be achieved at high flow rates, equal or more than 200 ml/min. Similarly, the existing portable water purifiers lack regional contaminant removal capabilities due to improper packaging and water flow path design.

To overcome the aforementioned issues, the present invention provides a pressure development device with inbuilt aeration capability and a multi stage purification cartridge with directional flow control. This novel combination allows the user to get biological, regional, and chemical contaminant-free water at high output flow rate.

SUMMARY OF THE INVENTION

The present invention discloses a portable water filtration system with region-specific impurity removal capabilities. The water filtration device consists of four major assemblies as follows:

1. A re-usable and washable pre-filter [20] for removal of particulate, suspended, and macroscopic impurities,
2. Hydrophilic hollow fiber and electrospun fiber membrane [17] for microfiltration & ultra-filtration, having pore size of less than or equal to 10 nanometers, to remove microbial contamination with high output water flux,

3. A compact modular annular housing filtration unit [30] with region-specific contaminant removing nano-composite materials housing [7] and activated biocidal charcoal, preferably nanomaterials decorated activated coconut charcoal housing [8] for biocidal activity and organic contaminant removal, and
4. A bellow pump unit [23] to develop pressure inside the feed water container reservoir [18].

In one embodiment, the present invention provides a portable hand-held, hand-operated, and electricity-free water purification device such as water purifying bottle for removing regional and regional-chemistry dictated contaminants, by a multi-step filtration process encompassing particulate filtration, filtration of regional and microbial contaminants using nano-materials and membranes, and filtration of organic materials with the help of carbon cartridge at a flow rate of equal to or greater than 200 ml/min. wherein the where regional contaminants are one or more from arsenic, iron, fluoride, uranium, lead, nickel, chromium, manganese, magnesium, cadmium, mercury and pesticides in the water soluble forms.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 a water purifying device.

Figure 2 shows a cross-sectional view of the device depicted in figure 1.

Figure3shows an exploded view of the device depicted in figure 1.

Figure 4 shows a cut-away sectional drawing of replaceable region-specific annular housing cartridge used with hollow fibre membrane cartridge.

Figure 5shows a sectional drawing of a bellow pump.

Figure 6 shows change in cartridge colour with use.

Referring to the drawings, the embodiments of the present invention are further described. The figures are not necessarily drawn to scale, and in some instances the drawings have been exaggerated or simplified for illustrative purposes only. One of ordinary skill in the art may appreciate the many possible applications and variations of the present invention based on the following examples of possible embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The following description is presented to enable any person skilled in the art to make and use the embodiments, and is provided in the context of a particular application and its requirements. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present disclosure. Thus, the present invention is not limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

An affordable portable purifier device involving multiple technologies for microbially, chemically and a heavy metal free drinking water.

To operate this bottle shown in figure 1, the user has to open the bottle from the back of bottle by rotating the back cap [24] which unscrews the compressed bellow housing [25] using a guided lock on protrusion [27]. In both expanded and compressed condition, bellow pump [23], shown in figure 5and back cap [24] are locked and line guided on bellow housing [25], which is threaded and fixed with the reservoir [18]. Contaminated feed water is filled into the reservoir [18] through feed water sponge [20] kept in pre-filter sponge housing [19]. Pre-filter sponge housing [19] is threaded onto reservoir [18]. Pre-filter [20] removes macro and suspended particulate matters. After completely filling the bottle, 80 – 100 ml of volumetric space remains open for atmospheric air, which later can be used for aeration of the contaminated water. After complete filling of feed water reservoir with the input contaminated water, complete bellow assembly [23 -27] is threaded on the pre-filter sponge housing [19] permanently fixed on the feed water reservoir [18]. Back cap [24], locked and guided on the bellow housing, is moved forward and backward to expand and compress the bellow pump and to create pressure inside the feed water reservoir [18] by pushing atmospheric air in it. This pumping mechanism generates pressure inside the feed water reservoir, preferably14 psi, more preferably above 14 psi, to perform microfiltration and ultrafiltration. The generated pressure with more than 14 psi pushes the contaminated water in contact with membrane housing [16] through the pores of the membrane. The pore size of microfiltration membrane used is preferably 1000 nanometers (nm), more preferably 100 nanometers while for ultrafiltration membrane the pore size is preferably 50 nm, more preferably 20 nm, more preferably 15 nm, and even more preferably 10 nm. When feed water passes through the hollow fiber membrane cartridge [17], nano or micro-sized biological impurities like bacteria, viruses, protozoa, along with dispersed micro particulates are

removed. Colour of the membrane cartridge changes with use from white to brown, red brown or black depending on the variety of contaminants present in feed water. All these parts are shown in details in figures. High hydrophilicity of hollow fiber and electrospun membrane cartridge [17] provides high filtered water flux, equal or more than 200 ml per minute for available membrane surface area. The treated water from the hollow fiber membrane cartridge [17] is then fed to the annular housing unit [30], shown in figure 4, where water is passed through a region-specific contaminant removal nano-composite materials [37]. These materials remove region-specific water-soluble contaminants, like arsenic, pesticides, and fluoride, etc., by adsorption. Subsequently, treated water moves [31] through nanomaterials decorated activated coconut charcoal [38] in housing [8] where soluble organic impurities and odor are removed and clean water is dispensed from bottle through the outlet pipe [35] to a chewable spout [2].

Hollow fibre membrane housing [16] and annular housing [30] are modular and designed in such a way that they can be replaced with new, once their contamination removal capacity is exhausted. Hollow fibre membrane housing [16] and annular housing [30] are connected to the feed water reservoir [18] through threads with food grade seals in-between to avoid leakages.

Annular Housing:

The compact annular housing [30], shown in figure 4 is a region-specific contamination filtration unit which houses both region-specific contaminant removal nano-composites materials [37] as well as silver nanoparticles decorated activated coconut charcoal [38] into a compact volume, used for region-specific contaminant removal and for biocidal performance and organic contaminant removal, respectively. In this housing, water direction is reversed to increase contact time. The unit packs the nanocomposite materials in the annular space between the walls [7] and [8], and the nanomaterials decorated charcoal filter material is packed between the walls [8] and [9]. The treated water from the hollow fiber membrane cartridge [16] enters the annular housing unit [30] through the holes [34] in disc [11]. The water first flows [32] through the region-specific contaminant removal nano-composite material housing and gets filtered by the nano-composites there and then it flows [31] through nanomaterials decorated activated coconut charcoal through the slots [5] made on the wall [8]. Here it is treated by nanomaterials, preferably silver nanoparticles with charcoal filter material. The flow of the out flowing water pushes it up the outlet pipe/tube [35] through the opening [10], from where it reaches the chewable spout [2], through which the user can drink the purified water.

Bellow Pump:

The bellow pump unit [23] as shown in figure 5 consists of a food grade plastic bellow [44] with spring [43] to ensure the reciprocatory expansion and compressions required to develop the pressure inside the feed water reservoir [18]. At the ends of the bellow pump [23] are attached custom made one-way umbrella valves [42] and [45]. The valves have rubber diaphragms [41] and [46] placed on them which controls the direction of the flow of air in the direction [40]. The one-way umbrella valve [45] is connected to the feed water reservoir [18] and pumps atmospheric air inside it. Valve [42] is left exposed to the atmosphere to inhale air from atmosphere. The arrangement of the diaphragms [41] and [46] ensure that when the bellow is compressed, the diaphragm [46] expands and allows the entry of air into the reservoir [18] while the diaphragm [41] restricts the entry of air into the bellow. Spring [43] ensures the expansion of the bellow resulting in the opening diaphragm [41] and simultaneously closing of diaphragm [46] which allows air from atmosphere into the bellow [23] due to which pressure is developed in the reservoir [18]. Bellow pump has food grade elastic O-ring [47] placed on the back side cover of the bellow valve which acts as a pressure regulator for the pressure developed in the reservoir depending on the plasticity and elasticity of the O-ring. Pressure developed in the reservoir is proportional to the elastic strength and excessively pumped air will be release back through the O-ring [47] seal.

Contaminations removal performance of presented device:

The following examples show the performance of the present invention. The examples should not be construed as limiting the scope of the invention.

EXAMPLE 1

Table 1: Removal of contaminants when feed water has only biological contamination

Input Parameters	**Input Water Quality**	**Output Water Quality**
Turbidity	Up to 200 NTU	< 1 NTU (WHO norm: 5 NTU)
Bacteria *(E.Coli.)*	10^5 CFU/ml	0 CFU/ml (WHO norm: 0 CFU/ml)
Virus	10^3 PFU/ml	0 PFU/ml (WHO norm: 0 PFU/ml)
pH	6 to 9	6.5 to 8

EXAMPLE 2

Table 2: Removal of contaminants when feed water has organic and biological contamination

Input Parameters	Input Water Quality	Output Water Quality
Turbidity	Up to 200 NTU	< 1 NTU (WHO norm: 5 NTU)
Bacteria *(E.Coli.)*	10^5 CFU/ml	0 CFU/ml (WHO norm: 0 CFU/ml)
Virus	10^3 PFU/ml	0 PFU/ml (WHO norm: 0 PFU/ml)
Chlorpyrifos	100 ppb	< 0.5 ppb (WHO norm: < 0.5 ppb
pH	6 to 9	6.5 to 8

EXAMPLE 3

Table 3: Removal of contaminants when feed water has metal, organic and biological contamination

Input Parameters	Input Water Quality	Output Water Quality
Turbidity	Up to 200 NTU	< 1 NTU (WHO norm: 5 NTU)
Bacteria *(E.Coli.)*	10^5 CFU/ml	0 CFU/ml (WHO norm: 0 CFU/ml)
Virus	10^3 PFU/ml	0 PFU/ml (WHO norm: 0 PFU/ml)
As(III) and As(V) in 1:1 ratio or mixture	200 ppb	< 10 ppb (WHO norm: < 10 ppb)
Fe(II) and Fe(III) mixture	4 ppm	< 300 ppb(WHO norm: < 300 ppb)
Aluminium	1 ppm	< 200 ppb(WHO norm: < 200 ppb)
Fluoride, preferably F^-	10 ppm	< 1.5 ppm (WHO norm: < 1.5 ppm)
Uranium, preferably UoO_2^-	300 ppb	30 ppb(WHO norm: < 30 ppb)
Mercury	200 ppb	< 1ppb (WHO norm: < 1 ppb)

Cadmium	200 ppb	3 ppb(WHO norm: < 3 ppb)
Cr(III) and Cr(VI) mixture	1 ppm	50 ppb(WHO norm: < 50 ppb)
Lead	200 ppb	10 ppb(WHO norm: < 10 ppb)
Chlorpyrifos	100 ppb	< 0.5 ppb (WHO norm: <0.5 ppb)
pH	6 to 9	6.5 to 8

In the above mentioned examples, each of the contaminants may be replaced with a plurality of contaminants.

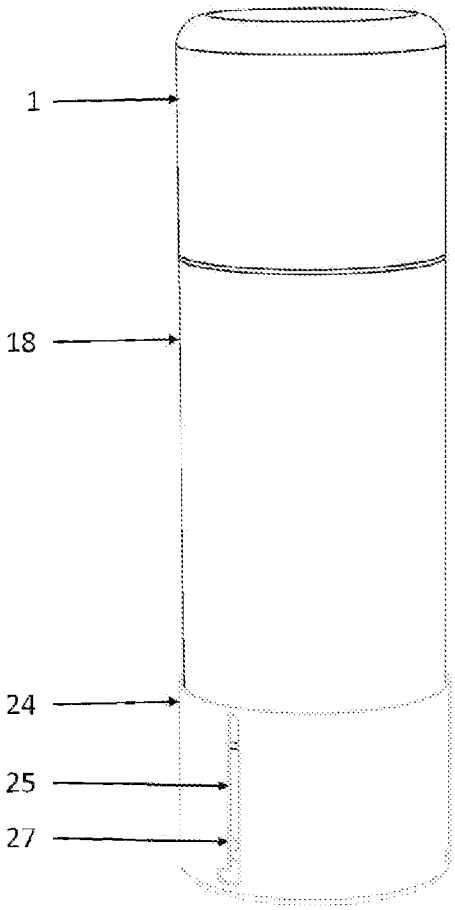
It may be appreciated by those skilled in the art that the drawings, examples and detailed description herein are to be regarded in an illustrative rather than a restrictive manner.

We Claim:

1. A portable hand-held, hand-operated and electricity-free water purification device for removing regional and regional-chemistry dictated contaminants, by a multi-step filtration process encompassing particulate filtration, filtration of regional and microbial contaminants using nano-materials and membranes, and filtration of organic materials by membrane and nanomaterial decorated carbon cartridge at a flow rate of equal to or greater than 200 ml/min.
2. A portable hand-held water purification device with region-specific impurity removal capabilities, having multi-step filtration assemblies, comprises of
    a) a re-usable and washable pre-filter for removal of suspended particulate and macroscopic impurities;
    b) hollow fiber and electrospun fiber membrane module for microfiltration and ultra-filtration, having pore size of less than or equal to 10 nanometers, to remove microbial contamination;
    c) a compact modular annular housing filtration unit with region-specific contaminant removing nano-composite materials housing and activated biocidal charcoal, preferably nanomaterials decorated activated coconut charcoal housing for biocidal activity and organic contaminant removal;
    d) a bellow pump unit to develop pressure inside the feed water container reservoir.
3. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the regional contaminants are one or more from arsenic, iron, fluoride, uranium, lead, nickel, chromium, manganese, magnesium, cadmium, mercury and pesticides in the water soluble forms.
4. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the membrane filtration is by hollow fiber membrane and electrospun membrane with flow rate equal to or greater than 200 ml/min.
5. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the nanomaterials decorated carbon filter that removes organic and metal ion contaminations at a concentration of less than 0-0.5 ppb with feed input of above 100 ppb.
6. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the purification occurs with the transverse flow of water in membrane cartridge and reverse directional flow in annular housing.

7. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the removal of multiple contaminants occurs in a sequence of particulate removal, turbidity removal, microbial removal, regional contaminant removal and organic contaminants removal.
8. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the color of the purifier cartridge has an in-built color indicator of cartridge life and its performance.
9. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the membrane cartridge uses electrospun membrane cartridge or hollow fiber membrane cartridge for microfiltration and ultrafiltration.
10. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the membrane comprises a top layer coating with a hydrophilic/hydrophobic ratio to increase output water flow rate with less pressure requirement.
11. The portable hand-held water purification device as claimed in claims 1 and 2, wherein the membrane cartridge is placed in preferential contact with feed water reservoir than the pumped atmospheric air.
12. The portable hand-held water purification device as claimed in claims1 and 2, wherein the membrane cartridge is capable of removing all dissolved solids.
13. The portable hand-held water purification device as claimed in claims1 and 2, wherein a re-usable washable pre-filter is made from cloth filter or sponge filter.
14. The portable hand-held water purification device as claimed in claims1 and 2, wherein a bellow pump is used to develop pressure inside the device.
15. The portable hand-held water purification device as claimed in claim 14, wherein the bellow pump is used with two umbrella valves and a spring for the expansion of the pump.
16. The portable hand-held water purification device as claimed in claim 14, wherein an O-ring shaped elastic spring rubber covers the back side of the bellow pump and acts as a pressure regulating valve for maintaining a predefined threshold of required pressure in the feed water container.
17. The portable hand-held water purification device as claimed in claim 16, wherein the O-ring shaped gasket is made of rubber, plastic or metal.

18. The portable hand-held water purification device as claimed in claims1 and 2, wherein a spout is used for potable water dispensing which additionally acts as a flow restrictor.
19. The portable hand-held water purification device filters impurities in multiple filtration processes using contaminant-specific purification cartridges, wherein the process involves
    a. an output water from the first stage of pre-filtration is fed to the second stage of membrane cartridge filtration
    b. an output of second stage filtration is fed to a third stage filtration of region-specific contaminant removal housing;
    c. an output from third stage filtration of region-specific contaminant removal housing is fed to nanomaterials decorated activated coconut charcoal housing, mineralization pellet and
    d. finally the output of nanomaterials decorated activated coconut charcoal housing is dispensed for drinking purpose through a spout.
20. The portable hand-held water purification device as claimed in claims1 and 2, wherein the device filters output water with arsenic concentration below 10 ppb with input concentration in the range of 10 ppb - 300 ppb.
21. The portable hand-held water purification device as claimed in claim 1 and 2, wherein the device filters microbial contaminations including bacterial and viral contaminants.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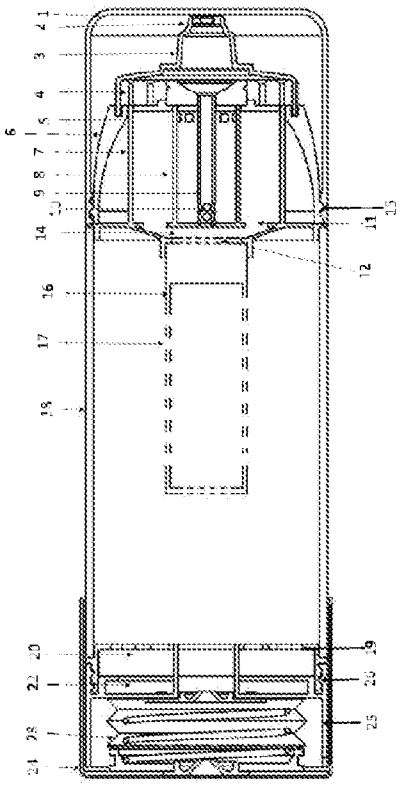
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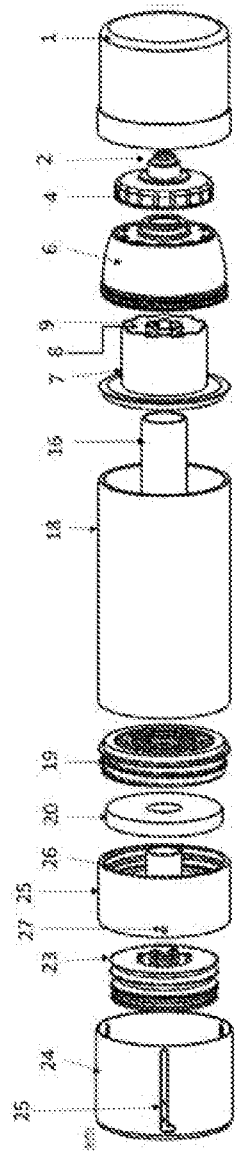
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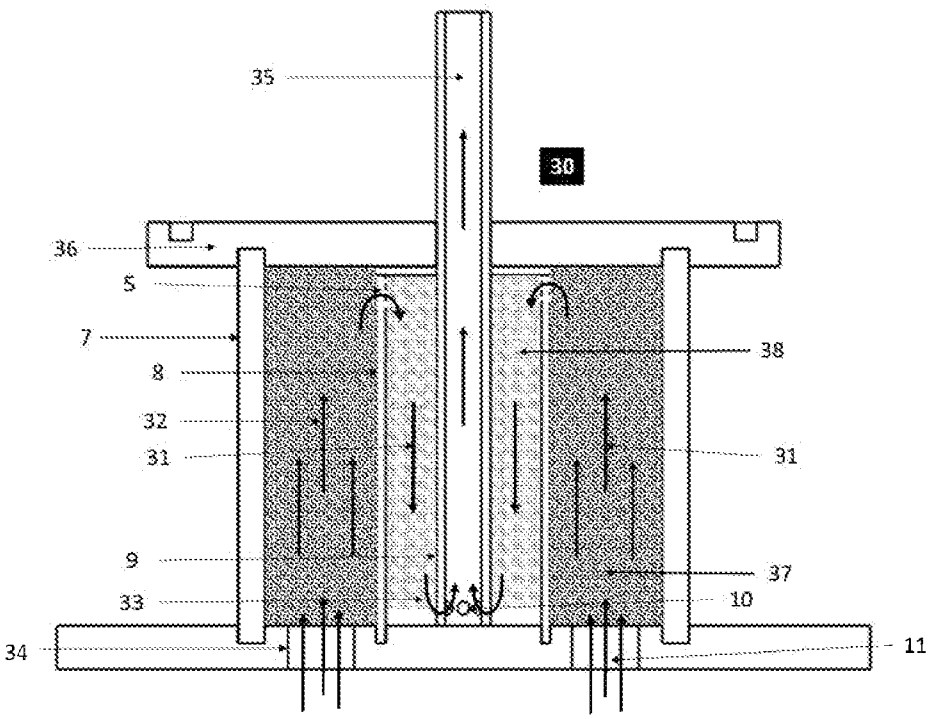
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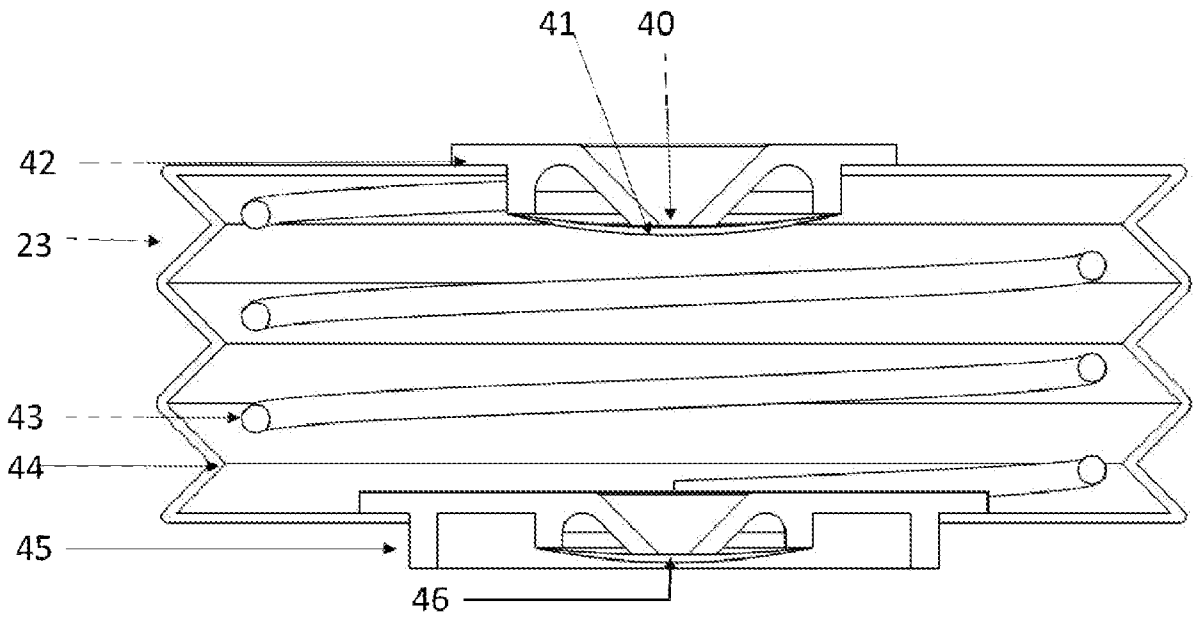
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New membrane
cartridge - White color
Used membrane
cartridge - Brown color

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2018/050895

A. CLASSIFICATION OF SUBJECT MATTER
C02F1/00,C02F1/28,B01D61/14,B01D63/02 Version=2019.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C02F, B01D

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

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

TotalPatent One, IPO Internal Database
Keywords used- water purification, ultrafiltration, particulate, activated carbon

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008110166 A1 (VESTERGAARD SA) 18.09.2008 (18 September, 2008) Abstract; Page 4 line 20-25; Page 10 line 30-35; Page 18 line 10-17; claim 25; fig 7	1, 19
Y	WO 2008110166 A1 (VESTERGAARD SA) 18.09.2008 (18 September, 2008) Abstract; Page 4 line 20-25; Page 10 line 30-35; Page 18 line 10-17; claim 25; fig 7	2-5, 7-18, 20-21
A	WO 2008110166 A1 (VESTERGAARD SA) 18.09.2008 (18 September, 2008) Abstract; Page 4 line 20-25; Page 10 line 30-35; Page 18 line 10-17; claim 25; fig 7	6
Y	WO 2012027242 A1 (Research Foundation of State University of New York) 01.03.2012 (01 March, 2012) Abstract; Para [0030], [0031]	2-5, 7-18, 20-21
Y	US 9468279 B2 (BLOKROK INC)18.10.2016 (18 October, 2016) Abstract; column 8 line 40-43; column 9 line 45-60	2-5, 7-18, 20-21

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

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"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
12-04-2019	12-04-2019
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Rajiv Ranjan Sinha Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2018/050895

Citation	Pub.Date	Family	Pub.Date
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