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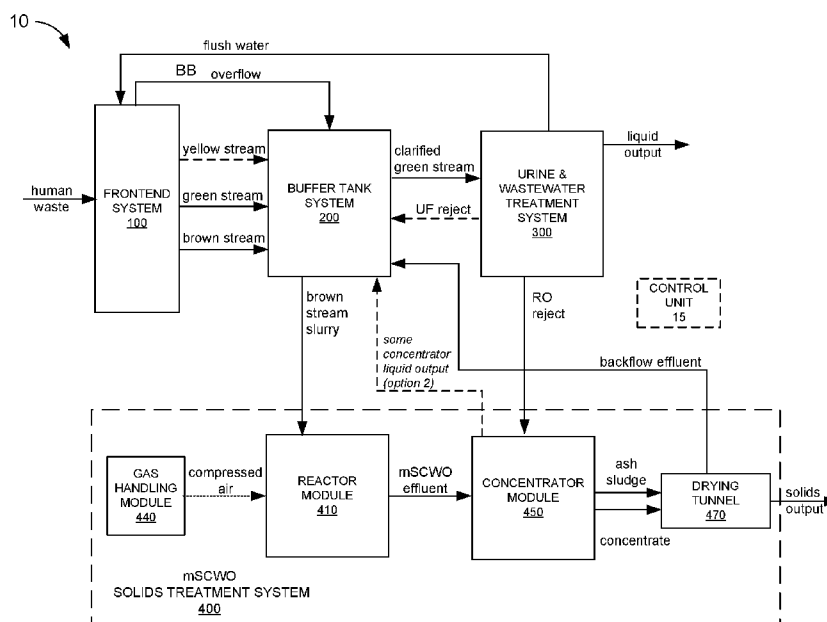


FIG. 1

(57) **Abstract:** A non-sewered toilet system and method for separation and treatment of human waste are described. The system can include a frontend system with a solids separator (100), a buffer tank separation system (200), a liquid waste treatment system (300), and a solids waste treatment system (400). The solids separator (100) can separate combined human waste including feces or urine into a separated solids portion and a separated liquid portion. The buffer tank separation system (200) can deliver a solids portion of the input stream to the solids collection tank and deliver the liquids portion to the liquids collection tank. The liquid waste treatment system (300) can receive liquid waste collected in the liquids collection tank and deliver a usable water. The solids waste treatment system (400) can receive a slurry from the solids collection tank, heat the slurry in a reactor to a temperature that is at or above the critical point of water to inactivate pathogens.

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WATER OXIDATION NON-SEWERED SINGLE UNIT TOILET SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to U.S. Provisional Application No. 63/222,726, titled “BUFFER TANK SEPARATION AND HOMOGENIZATION SYSTEM,” filed on July 16, 2021; U.S. Provisional Application No. 63/222,738, titled “URINE AND WASTEWATER TREATMENT SYSTEM,” filed on July 16, 2021; U.S. Provisional Application No. 63/222,736, titled “MICRO SUPER CRITICAL WATER OXIDATION SOLIDS TREATMENT SYSTEM,” filed on July 16, 2021; and U.S. Provisional Application No. 63/338,998, titled “HUMAN WASTE COLLECTION AND SEPARATION SYSTEM,” filed on May 6, 2022, the entire contents of all of which applications are hereby incorporated herein by reference.

BACKGROUND

[0002] An estimated 4.5 billion people worldwide do not have access to safe, affordable sanitation systems. High levels of child death and disease have been linked to oral fecal contamination where pathogen laden fecal matter enters the food or water supply. Non-sewered sanitation systems are needed where traditional sanitary sewer systems are unavailable or impractical.

SUMMARY

[0003] Disclosed herein is non-sewered toilet system, comprising a frontend separation system, a buffer tank separation system, a liquid waste treatment system, and a water oxidation solids waste treatment system. The solids waste treatment system can receive a slurry from the solids collection tank, heat the slurry in a reactor to a temperature that is at or above the critical point of water to inactivate pathogens. The non-sewered single unit toilet system is configured to produce a useable water and pathogen free solid waste.

[0004] The frontend separation system comprises a solids separator and is configured to receive a combined waste and separate the combined waste into a separated solids portion and a separated liquid portion and the separated solids portion comprising mostly solids and some fluid and the separated liquid portion comprising mostly fluid with some solids, the combined waste comprising at least one of urine and feces.

[0005] The buffer tank separation system comprises a liquids collection tank, a solids collection tank, and a belt separator, the belt separator positioned to receive an input stream comprising at least one of: the separated solids portion and the separated liquids portion from the frontend separation system, the belt separator configured further separate the input stream to deliver a solids portion of the input stream to the solids collection tank and to deliver the liquids portion of the input stream to the liquids collection tank.

[0006] The liquid waste treatment system is configured to receive liquid waste collected in the liquids collection tank of the buffer tank separation system and comprises an ultra-filtration stage comprising an ultra-filtration filter configured to separate the liquid waste into a first permeate and a first concentrate, and a reverse osmosis stage configured to receive a first permeate from the ultra-filtration stage and separate the first permeate into a second permeate and a second concentrate, the second permeate being a useable water.

[0007] The solids waste treatment system is configured to receive a feces slurry from the buffer tank separation system, the feces slurry comprising the solids waste collected in the solids collection tank and comprises an injector vessel; a reactor configured to receive an injection of a slurry batch of the feces slurry from the injector vessel and an input of compressed air to be heated to a temperature over a heating time, the temperature being at or above the critical point of water into the super critical fluid phase; and a combined concentrator and phase separator comprising: a concentrator vessel configured to receive and contain a liquid to be concentrated; and a separator configured to receive a treated output from the reactor and separate solid ash volume from liquid and gaseous effluent.

[0008] Also disclosed herein are methods for treating human waste using the disclosed system.

[0009] Other systems, methods, features, and advantages of the present disclosure will be or become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present disclosure, and be protected by the accompanying claims. In addition, all optional and preferred features and modifications of the described embodiments are usable in all aspects of the disclosure taught herein. Furthermore, the individual features of the dependent claims, as well as all optional and

preferred features and modifications of the described embodiments are combinable and interchangeable with one another.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Many aspects of the present disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily drawn to scale, with emphasis instead being placed upon clearly illustrating the principles of the disclosure. In the drawings, like reference numerals designate corresponding parts throughout the several views.

[0011] FIG. 1 illustrates an example schematic of a water oxidation non-sewered single unit toilet system according to various embodiments described herein.

[0012] FIG. 2 illustrates an example method for human waste separation and treatment using water oxidation non-sewered single unit toilet system of FIG. 1 according to various embodiments described herein.

[0013] FIGS. 3A and 3B illustrate schematic diagrams of example frontend separation system of the water oxidation non-sewered single unit toilet system of FIG. 1 according to various embodiments described herein.

[0014] FIG. 4 illustrates an example solids separator for a frontend separation system shown in FIGS. 3A and 3B according to various embodiments described herein.

[0015] FIG. 5 illustrates a cross section of a frontend solids separator of FIG. 4 according to various embodiments described herein.

[0016] FIG. 6 illustrates the separation of the solids and liquids within the solids separator of FIG. 4 according to various embodiments described herein.

[0017] FIG. 7 illustrates an example method for human waste collection and separation according to various embodiments described herein.

[0018] FIG. 8 illustrates an example schematic diagram of a buffer tank separation and homogenization system of the water oxidation non-sewered single unit toilet system of FIG. 1 according to various embodiments described herein.

[0019] FIGS. 9A-9C illustrate perspective and side views of an example belt separator for the buffer tank separation and homogenization system of FIG. 8 according to various embodiments described herein.

[0020] FIG. 10 illustrates an example buffer tank separation and homogenization system of FIG. 1 according to various embodiments described herein.

[0021] FIG. 11 illustrates cross-sectional view of the buffer tank separation and homogenization system of FIG. 10 according to various embodiments described herein.

[0022] FIG. 12 illustrates an example method for using a buffer tank separation and homogenization according to various embodiments described herein.

[0023] FIGS. 13A-13D illustrate example flow and separation for various waste events using the buffer tank separation and homogenization system according to various embodiments described herein.

[0024] FIG. 14 illustrates an example schematic diagram of a urine and wastewater treatment system of the water oxidation non-sewered single unit toilet system of FIG. 1 according to various embodiments described herein.

[0025] FIG. 15 illustrates an example method for urine and wastewater treatment according to various embodiments described herein.

[0026] FIG. 16 illustrates an example diagram of a micro-Super Critical Water Oxidation (mSCWO) solids treatment system of the water oxidation non-sewered single unit toilet system of FIG. 1 according to various embodiments described herein.

[0027] FIG. 17 illustrates example portions the gas handling module and reactor module of a mSCWO solids treatment system of FIG. 16 according to various embodiments described herein.

[0028] FIG. 18 illustrates an example cross sectional view of the mSCWO reactor of the mSCWO solids treatment system of FIG. 16 according to various embodiments described herein.

[0029] FIGS. 19A-19B illustrate an example concentrator module of the mSCWO solids treatment system of FIG. 16 according to various embodiments described herein.

[0030] FIG. 20 illustrates an example of the drying tunnel of the mSCWO solids treatment system of FIG. 16 according to various embodiments described herein.

[0031] FIG. 21 illustrates an example method for treatment of solids waste using the mSCWO solids treatment system of FIG. 16 according to various embodiments described herein.

DETAILED DESCRIPTION

[0032] Sanitation systems are needed for regions of the world where open defecation or lack of improved sanitation is common, which can lead to illness. Traditional sewage and wastewater treatment plants which receive waste from sewers can be expensive to implement and operate. Technologies for multi-unit toilets are being developed to process waste on a large scale.

However, there is a need for technology to provide access to safe, affordable sanitation systems that can be deployed in a family home without sewer connections. Holistically, as water scarcity rises across the globe, sanitation systems that reduce reliance on large volumes of water for transport of waste over long distances will become increasingly important, not just in developing countries, but globally.

[0033] To address these deficiencies, various examples of non-sewered single unit toilet systems and methods are disclosed herein. The non-sewered single unit toilet systems are configured to inactivate pathogens from human waste and prepare waste for safe disposal. The non-sewered single unit toilet systems can also recover valuable resources such as clean water. The non-sewered single unit toilet systems can be configured to operate without connection to input water or output sewers. Some example non-sewered single unit toilet systems can be battery based or powered by off-grid renewables. The non-sewered single unit toilet systems can be optimized for low-cost fabrication and low operation costs. The non-sewered single unit toilet systems can promote sustainable sanitation services that operate in poor, urban settings, as well as in developed and developing nations.

[0034] The water oxidation non-sewered single unit toilet system can be configured for stand-alone use. In some examples, the non-sewered single unit toilet system can be configured to provide treated output that meets or exceeds the ISO 30500 standard. The ISO 30500 standard provides a technical standard for non-sewered sanitation systems designed to address basic sanitation needs and promote economic, social, and environmental sustainability through strategies that include minimizing water and energy consumption and converting human excreta to safe output. These sanitation systems are intended to operate without connection to any sewer or drainage network and meet health and environmental safety and regulatory parameters.

[0035] For example, for liquid output, the ISO 30500 reuse standards include chemical oxygen demand (COD) ≤ 50 mg/L, total Nitrogen (N) $> 70\%$ reduction, total Phosphorus (P) $> 80\%$ reduction, pH: 6.0-9.0, total suspended solids (TSS) ≤ 10 , and *Escherichia coli* (*E. coli*) ≤ 100 per L. In another example, discharge standards include chemical oxygen demand (COD) ≤ 150 mg/L, total Nitrogen (N) $> 70\%$ reduction, total Phosphorus (P) $> 80\%$ reduction, pH: 6.0-9.0, total suspended solids (TSS) ≤ 30 , and *E. coli* ≤ 100 per L. For example, the *E. coli* counts in final solid output can be less than 100 per g. Additionally, a gas filter can be configured so that the filtered gas released from the system is ISO 30500 compliant. For example, the non-sewered

single unit toilet system can be configured to render the bodily wastes of an adult human into water, CO₂, and mineral ash.

[0036] In an example, the non-sewered single unit toilet system can receive unrestricted rates of mixed-content human waste streams and sanitation incidentals. For example, human waste streams can include urine, feces, diarrhea, and the like. For example, sanitation incidentals can include toilet paper, feminine hygiene waste, diapers, other paper products, and the like. In some toilet systems, a portion of sanitation incidentals, including non-organic products such as diapers, can be received and processed separately from the human waste streams. In some examples, the waste streams comprise human feces and urine, menstrual blood, bile, flushing water, anal cleansing water, toilet paper, other bodily fluids and/or solids. Additionally, the waste streams that comprise water, as described herein, can include flush water, rinse water, wash water, fresh water, consumable water, potable water, non-potable water, useable water, and the like.

[0037] The non-sewered single unit toilet system can be configured to separate or process the content of human waste streams separately. Separation of streams can provide more efficient processing than mixed-content human waste streams by dividing the source material into primarily feces, urine, and wastewater streams. Since 100% separation is not practical, a degree of cross contamination between the streams is acceptable for the subsequent downstream treatment approaches. As described herein, the feces stream, containing primarily feces, is also referred to as the “brown stream.” The brown stream is mostly feces, but can also be mixed with other liquid and solid waste. For example, the brown stream can include feces, toilet paper, some urine, and some water. As described herein, the “green stream” can include mostly water, some urine, and some toilet paper, and usually does not include feces. The green stream is mostly liquid with some solids. As described herein, a urine stream, containing primarily urine, is also referred to as the “yellow stream.” For example, a yellow stream can include urine and some water. As described herein, the wastewater stream is also referred to as the “blue stream.” For example, the blue stream can contain primarily wastewater in the form of flush water, anal rinse water, or excess water that is poured into the toilet. In some examples, the blue stream can also include some urine. Stream separation can enable lower cost and more robust treatment processes given the high degree of variability in low volume fecal deposits (recognized as primarily diarrhea), high volume urine deposits, and excessive amounts of flush and anal rinse water, given future water scarcity constraints.

[0038] The non-sewered single unit toilet system can be configured to provide the type of toilet configuration that is acceptable in a particular region of the world. For example, the non-sewered single unit toilet system can be configured to have a main vessel or toilet bowl for collecting human waste that is adapted for either a squat configuration or a pedestal configuration. Additionally, the frontend separation system can be configured to accommodate users that wipe using toilet paper or rinse with water. The frontend separation system can accommodate standing urinators.

[0039] In this context, the non-sewered single unit toilet system can be used to receive human waste from urination and/or defecation toilet events, separate the combined human waste into liquids and solids, and reduce the separated liquids and solids to a safe output. In some examples, one or more components of the non-sewered single unit toilet system can include a vent outlet to release air or any gas formed in the components of the system. The gas filter can be configured so that the filtered gas released from the system is ISO 30500 compliant. For example, the non-sewered single unit toilet system can be configured to render the bodily wastes of an adult human into water, CO₂, and mineral ash.

[0040] FIG. 1 illustrates an example schematic of a water oxidation non-sewered single unit toilet system 10. The water oxidation non-sewered single unit toilet system 10 can comprise a frontend separation system 100, also referred to as the human waste collection and separation system herein, a buffer tank separation system 200, also referred to as the buffer tank separation and homogenization system herein, a urine and wastewater treatment system 300, and a micro Super Critical Water Oxidation (mSCWO) treatment system 400, also referred to as a solids treatment system or water oxidation solids treatment system herein. As will be described in further detail, one or more of the frontend separation system 100, the buffer tank separation system 200, the urine and wastewater treatment system 300, and the water oxidation solids treatment system 400 can be considered interconnected to receive input from one or more systems within the water oxidation non-sewered single unit toilet system 10. The water oxidation non-sewered single unit toilet system 10 can also include a control unit 15 comprising a main controller configured to control or operate one or more valves, pumps, motors, sensors, and other devices in the water oxidation non-sewered single unit toilet system 10.

[0041] The frontend separation system 100, also referred to as the frontend or frontend system herein, can be configured to receive and separate human waste from urination and/or defecation

toilet events. For example, the frontend separation system 100 can be configured to be a frontend module to receive human waste, water, and/or toilet paper for the water oxidation non-sewered single unit toilet system 10. Flush water can be received from the urine and wastewater treatment system 300 or from an external source. The frontend separation system 100 can be configured to process mixed human waste and separate the waste into one or more different output streams for further processing and/or treatment. For example, the human waste combined with water and/or toilet paper can be separated into at least two streams: a mostly liquid stream and a mostly solids stream. As described above, the mostly liquid stream, also called the green stream herein, and can contain a proportionally small amount of solids. Mostly liquid can mean less than 5% solid content by volume. The mostly liquid stream, or green stream, can comprise flush water, some urine, some feces, and some toilet paper. As described above, the mostly solids stream, also called the brown stream herein, can contain mostly solids and some liquids. Mostly solids can mean about 1% to about 25% dry solids content by mass. The mostly solids stream, or brown stream, can comprise feces, flush water, urine, and toilet paper. In some examples, a third output stream comprising mostly urine can be diverted prior to separating the combined waste, thus reducing the volume of combined waste to be separated. This mostly urine stream, or yellow stream, can comprise urine and trace amounts of flush water. It is noted that the yellow, green, and brown streams are defined by the composition of human waste as described herein, not by the actual color of the physical stream.

[0042] For example, the frontend separation system 100 can comprise a vessel 102 or 122, a flush tank 104, and solids separator 106 (FIGS. 3A and 3B). The vessel 102 or 122 can receive human waste comprising at least one of: urine and feces. The flush tank 104 can be configured to deliver a volume of flush water to the vessel to form a combined waste with the human waste within the vessel. The solids separator 106 can be configured to evacuate the combined waste from the vessel and separate the combined waste into a separated solids portion and a separated liquid portion and the separated solids portion comprising mostly solids and some fluid and the separated liquid portion comprising mostly fluid with some solids. The frontend separation system 100 will be described in further detail herein.

[0043] The buffer tank separation and homogenization system 200 can receive the one or more output streams from the frontend separation system 100. For example, the buffer tank separation and homogenization system 200 can separately receive the green and brown stream

which have been separated by the from the frontend separation system 100. In some examples, a yellow or urine stream can also be received. The buffer tank separation and homogenization system 200 can be a dual chamber tank system for the short-term storage and fractional passive separation of liquid from solid human waste and toilet paper. For example, the buffer tank separation and homogenization system 200 can receive and further separate the solids and liquids of the green stream and brown stream. The buffer tank separation and homogenization system 200 can clarify the green stream by removing solids. For example, the clarified green stream can be part of a liquids output of the buffer tank separation and homogenization system 200 that can be routed to a urine and wastewater treatment system 300 for filtering to produce useable water. The useable water described herein can include non-potable water for use or re-use. The buffer tank separation and homogenization system 200 can remove excess liquid from the brown stream to produce a brown slurry to be delivered to the water oxidation solids treatment system 400 for removal or destruction of pathogens.

[0044] The buffer tank separation and homogenization system 200 can include a mechanism to separate and deliver the solid toilet paper from the green stream to a solids tank and the liquids from the brown stream to a liquids tank. Further, in some examples, the buffer tank separation and homogenization system 200 can receive a yellow stream from the frontend unit that collects and separates a mixed waste. Additionally, recirculation input streams can be received into the buffer tank separation and homogenization system 200. For example, the buffer tank separation and homogenization system 200 can recirculate the contents of the solids and liquids tanks within the system. Also, the buffer tank separation and homogenization system 200 can receive and process streams from the urine and wastewater treatment system 300 and water oxidation solids treatment system 400. For example, a filter concentrate can be received from a urine and wastewater treatment system 300 and a liquid effluent can be received from a water oxidation solids treatment system 400 for further processing.

[0045] The primary output streams from the buffer tank separation and homogenization system 200 are a collected liquids stream and a collected solids slurry, also called a feces slurry herein. The collected solids or “brown” slurry can comprise feces, flush water, toilet paper and urine. A homogenizer, similar in design and operation to a bladed macerator, can be used to transform the collected solids output in the solids tank into a uniform and homogenized slurry for transport to the water oxidation solids treatment system 400. In some examples, the homogenizer

can be incorporated into the solids tank design. The brown slurry can be delivered to the water oxidation solids treatment system 400. The liquid effluent or collected liquids from the liquids tank can be pumped from the liquids tank to a urine and wastewater treatment system 300 and can comprise urine, flush water, and trace amounts of toilet paper or other solids. In some examples, the buffer tank system 200 can also receive an overflow from the frontend separation system 100, an ultra-filtration (UF) reject input from the urine and wastewater treatment system 300, and/or a filtrate and/or condensed effluent from the water oxidation solids treatment system 400.

[0046] For example, the buffer tank separation system 200 can comprise a belt separator 204, a liquids collection tank 206, and a solids collection tank 208 (FIG. 8). At least one inlet can comprise a first inlet configured to receive the separated liquid portion of the combined waste and a second inlet configured to receive the separated solids portion of the combined waste from the frontend separation system 100. The belt separator 204 can be positioned to receive an input stream via the at least one inlet onto the belt of the belt separator 204. The input stream can comprise at least one of: the separated solids portion and the separated liquids portion from the frontend separation system 100. The belt separator 204 can be configured to deliver a solids portion of the input stream to the solids collection tank 208 and to deliver the liquids portion of the input stream to the liquids collection tank 206. The liquids collection tank 206 can comprise a liquids outlet configured to release collected liquids. The solids collection tank 208 can comprise a solids outlet configured to release collected solids. In some examples, buffer tank separation system 200 further comprises a homogenizer 210 connected to the solids outlet and configured to receive the collected solids portion and form a uniform and homogenized slurry. The buffer tank separation system 200 will be described in further detail herein.

[0047] The urine and wastewater treatment system 300 can receive the collected liquids output, also referred to as a clarified green stream herein, from the buffer tank separation system 200. The urine and wastewater treatment system 300 can be used to process a liquid stream containing mostly urine, or a green stream of human waste. By separating the green stream prior to input, the urine and wastewater treatment system 300 can operate to process the liquids contained therein. The urine and wastewater treatment system 300 is configured to produce usable water as a liquid output or for flush water in the frontend separation system 100.

[0048] The urine and wastewater treatment system 300 can include a membrane filtration process for the removal of pathogens and chemical contaminants from liquid human waste to

produce water suitable for recirculated toilet flushing or safe discharge. The liquid waste, primarily composed of urine, flush water and trace toilet paper, can pass through a series of filtration stages including an ultra-filtration stage and reverse osmosis stage. Each filtration stage can have an associated reservoir tank and pump component enabling each filtration to operate at the most effective pressure. The rejected concentrate can be recirculated through the filtration stages before diversion to a concentration process for discharge. The permeate can be collected and either recirculated to act as flush water in the toilet system or discharged depending on the system requirements. For example, the liquid permeate of the water oxidation non-sewered single unit toilet system 10 can meet ISO 30500 reuse or discharge standards.

[0049] For example, the urine and wastewater treatment system 300 can receive liquid waste collected in the liquids collection tank 206 of the buffer tank separation system 200. The urine and wastewater treatment system 300 can comprise an air blower 314 and a filtration unit an ultra-filtration stage comprising an ultra-filtration filter 304 and a reverse osmosis stage comprising a reverse osmosis filter 312 (FIG. 14). The air blower 314 can be configured to blow air into the liquid waste to reduce the density of the liquid waste and to generate crossflow. The filtration unit can include an ultra-filtration stage and a reverse osmosis stage. The reverse osmosis stage configured to receive a first permeate from the ultra-filtration stage and deliver a usable water. The urine and wastewater treatment separation system 300 will be described in further detail herein.

[0050] The mSCWO solids treatment system 400 can receive input from the buffer tank separation and homogenization system 200 as a feces slurry, also referred to as a brown slurry or brown stream slurry herein, and produce a pathogen free solids output. The mSCWO solids treatment system 400 can be configured to process a feces stream or brown stream of human waste. By separating the brown stream prior to input, the mSCWO solids treatment system 400 can operate to process the solids contained therein. Moreover, a brown stream slurry can be obtained by removing excess fluid from the brown stream and homogenizing the contents. The mSCWO solids treatment system 400 can also receive an input from the urine and wastewater treatment system 300 which can be processed and added to ash output from the water oxidation solids treatment system 400.

[0051] The mSCWO solids waste treatment system 400 can include a reactor module 410, a gas handling module 440, and a concentrator module 450. The mSCWO solids treatment system

400 can be configured to receive and process a solids slurry comprising at least feces, also referred to as a feces slurry herein. The reactor module 410 of the mSCWO solids treatment system 400 can receive a brown stream slurry or feces slurry from the buffer tank separation and homogenization system 200. The gas handling module 440 can be configured to inject pressurized air into the reactor module 410. The slurry batch can be heated to a temperature that is at or above the critical point of water into the super critical fluid phase and maintained at a minimum temperature, for example a temperature greater than the critical point of water. The concentrator module 450 can be configured to receive an mSCWO effluent from the mSCWO reactor module 410. The reactor module 410 comprise a separator 452 and concentrator 454 (FIG. 16). For example, the separator can receive the mSCWO effluent and deliver an ash sludge to the drying tunnel 470. Additionally, the concentrator module 450 can receive rejected liquid waste containing solids from the urine and wastewater system 300. The liquid waste can be concentrated in the concentrator 454 of the concentrator module 450. The concentrate output can be delivered to the drying tunnel to produce solids output. In another example, a portion of the concentrator liquid output can be delivered to the buffer tank separation system 300. The water oxidation solids treatment system 400 will be described in further detail herein.

[0052] The water oxidation non-sewered single unit toilet system 10 can also include control unit 15 can comprise a main controller configured to control or operate one or more valves, pumps, motors, sensors, and other devices in the water oxidation non-sewered single unit toilet system 10. As described in further detail below, the water oxidation non-sewered single unit toilet system 10 can also comprise individual controllers for each of the frontend separation system 100, the buffer tank system 200, the urine and wastewater treatment system 300, and the water oxidation solids treatment system 400. The main controller of control unit 15 and other individual controllers can be embodied in the form of hardware, firmware, software executable by hardware, or as any combination thereof, including at least one processor or processing circuit and a memory device. Although the other controllers are shown schematically as separate controllers herein, the controllers can also be configured to operate the individual systems or embodied as part of the control unit 15. For example, controller 115 in FIGS. 3A and 3B, controller 215 in FIG. 8, controller 315 in FIG. 14, and controller 415 in FIG. 16 can be embodied as part of control unit 15.

[0053] FIG. 2 shows an example method for separation of human waste and removal of pathogens using the water oxidation non-sewered single unit toilet system 10 of FIG. 1 as described herein. The example method for separation of human waste and removal of pathogens using the water oxidation non-sewered single unit toilet system 10 can include additional steps as related to the method and operation of the frontend separation system 100, the buffer tank separation system 200, the urine and wastewater treatment system 300, and the mSCWO solids treatment system 400 as shown and described herein.

[0054] At box 1002, receive a human waste into a vessel 102 or 122 of a frontend separation system 100. The human waste can be at least one of urine and feces. In some examples, the human waste can be combined with at least one of water and toilet paper. The water can be flush water, rinse water, wash water, fresh water, consumable water, potable water, non-potable water, useable water, or other water that is compatible for use with the water oxidation non-sewered single unit toilet system. In some examples, suitable cleaning compositions, such as a cleaning fluid or powder, can be deposited and combined with water in the vessel to clean the vessel then flushed can also be considered human waste herein. The frontend separation system 100 can receive flush water for to be used in the vessel from the urine and wastewater system 300. In some examples, an overflow from the frontend separation system 100 can be directed to the buffer tank separation system 200.

[0055] At box 1004, separate the human waste into at least one of a mostly liquid stream and a mostly solids stream. The human waste received into the vessel 102 or 122 of the frontend separation system 100 can be combined with at least a volume of water to form a combined waste. The combined waste can be evacuated from the vessel 102 or 122 into a frontend solids separator 106. A liquids portion of the combined waste can be separated through a separating filter 134 to collect the liquids in the liquids containment portion 162. The solids portion of the combined waste can be retained within the separating filter 134 and collected in the solid containment portion 160 of the frontend solids separator 106. Additional features of the frontend separation system 100 and operation thereof are shown in FIGS. 3A-7 and described herein.

[0056] At box 1006, deliver the mostly liquid stream from the frontend separation system 100 to a buffer tank separation system 200. The mostly liquid stream can be less than 5% solid content by volume. In some examples, when the vessel 122 comprising a urine diverter 124 is used, an

additional separate a urine stream from the human waste can be delivered from a urine tank 126 to the buffer tank separation system 200 or some other system for further processing.

[0057] At box 1008, receive the mostly liquid stream via a first inlet onto a belt separator 204 and separate at least some of the solids from the mostly liquid stream. At box 1010, deposit the solids separated from the mostly liquid stream into the solids collection tank 208 and deposit the remaining portion of the mostly liquid stream into a liquids collection tank 206 for short-term storage and passive separation of liquid from remaining solid waste received into the liquids collection tank. In some examples, when the vessel 122 is used, the urine stream delivered from the urine tank 126 can be received via an alternate inlet onto the belt separator to remove any trace solids and direct the urine to the liquids tank. The urine stream can comprise mostly urine, some water, and trace solids.

[0058] At box 1012, deliver the mostly solids stream from the frontend separation system to the buffer tank separation system. The mostly solids stream is about 1% to about 25% solid content by volume.

[0059] At box 1014, receive the mostly solids stream via a second inlet onto the belt separator and separate most of the solids from the mostly solids stream. At box 1016, deposit the solids separated from the mostly solids stream into the solids collection tank and deposit the remaining portion of the mostly solids stream into the liquids collection tank for short-term storage and passive separation of liquid from remaining solid waste received into the liquids collection tank. Additional features of the buffer tank separation system 200 and operation thereof are shown in FIGS. 8-13D and described herein.

[0060] At box 1018, separate pathogens from a liquid waste received from a volume of collected liquids separated within the liquids collection tank in a urine and wastewater treatment system. In some examples, solids in the remaining portion of the mostly liquid stream can form a sludge by sedimentation at the bottom of the liquids collection tank 206. In some examples, the sludge can be delivered to the belt separator 204 via an alternate inlet and solids removed from the sludge and delivered to the solids tank 208. Additional features of the urine and wastewater treatment system 300 and operation thereof are shown in FIGS. 14-15 and described herein.

[0061] For example, separating pathogens from a liquid waste received from a volume of collected liquids separated within the liquids collection tank in a urine and wastewater treatment system can comprise: receiving a liquid waste comprising the volume of collected liquids separated

within the liquids collection tank; blowing air into the liquid waste to reduce the density of the liquid waste and to generate crossflow; filtering the liquid waste in an ultra-filtration stage to separate a first permeate and a first concentrate; discharging the first concentrate to the buffer tank system; filtering the first permeate in a reverse osmosis stage to separate a second permeate and a second concentrate; recirculating the second concentrate to filter in reverse osmosis stage; and discharging the second permeate as useable water.

[0062] At box 1020, deliver a volume of collected solids settled within the solids collection tank to a homogenizer to form a feces slurry. In some examples, a portion of the contents of the solids collection tank 208 can be delivered to the belt separator 204 via an alternate inlet and solids removed from the portion and delivered to the solids tank 208 and liquids delivered to the liquids collection tank 206.

[0063] At box 1022, inactivate pathogens of the feces slurry in a water oxidation solids treatment system. Additional features of the water oxidation solids treatment system 400 and operation thereof are shown in FIGS. 16-21 and described herein. For example, inactivating pathogens from the feces slurry in a water oxidation solids treatment system can comprise: For example, inactivating pathogens of the feces slurry can include receiving a slurry batch of feces into an injector vessel; pressurizing the slurry batch with air; heating the slurry batch, within the reactor, for a heating time to a temperature that is at or above the critical point of water into the super critical fluid phase; maintaining the slurry batch at a minimum temperature, within the reactor, for a predetermined treatment time to produce a treated output, wherein the minimum temperature is greater than the critical point of water; and separating the treated output into a solid ash volume, a liquid waste, and a gaseous effluent. The solid ash volume can be an ash sludge. In an example, the slurry batch can be received in an optional homogenizer of the reactor module before being delivered into the injector vessel. Additionally, the concentrator module can be configured to receive and contain a liquid waste to be concentrated from the urine and wastewater treatment system 300 into a concentrator of the concentration and release the concentrate as solids output.

[0064] As can be understood, the example method can be carried out in the order recited or in any other order that is logically possible. The method can omit steps or include additional steps. For example, the method can include additional steps as described in FIGS. 7, 12, 15, and 21 as described herein.

[0065] In the following discussion, a general description of the frontend separation system 100, the buffer tank separation system 200, the urine and wastewater treatment system 300, and the water oxidation solids treatment system 400 and their components is provided, including a discussion of the operation of the same. Non-limiting examples the water oxidation non-sewered single unit toilet system 10 and methods are discussed.

[0066] FRONTEND SEPARATION SYSTEM

[0067] In FIGS. 3A-6, the frontend separation system 100 of the water oxidation non-sewered single unit toilet system 10 is shown in greater detail. The frontend separation system 100 can process mixed human waste and separate the waste into at least two different output streams for further processing and/or treatment. The human waste combined with water and/or toilet paper can be separated into at least two streams: a mostly liquid stream and a mostly solids stream. As described above, the mostly liquid stream, also called the green stream herein, and can contain a proportionally small amount of solids. The mostly liquid stream, or green stream, can comprise flush water, some urine, some feces, and some toilet paper. As described above, the mostly solids stream, also called the brown stream herein, can contain mostly solids and some liquid. The mostly solids stream, or brown stream, can comprise feces, flush water, urine, and toilet paper. In some examples, a third output stream comprising mostly urine can be diverted prior to separating the combined waste, thus reducing the volume of combined waste to be separated. This mostly urine stream, or yellow stream, can comprise urine and trace amounts of flush water. It is noted that the yellow, green, and brown streams are defined by the composition of human waste as described herein, not by the actual color of the physical stream.

[0068] As illustrated in FIG. 3A, the frontend separation system 100 can comprise a main vessel 102, a flush tank 104, and a frontend solids separator 106. The frontend separation system 100 can also include a user interface panel 108, a controller 115, and a vacuum pump 112. The main vessel 102 can be a toilet bowl configured to receive human waste, such as urine and feces, as well as toilet paper. After a urination and/or defecation event, a volume of flush water, received from the flush tank 104, can be added to the main vessel 102 forming a combined waste within the vessel. The combined waste can be evacuated through a main outlet 114 of the main vessel 102 into the solids separator 106. The combined waste received into the solids separator 106 can be separated into a liquid portion comprising mostly liquids with some solids and a solids portion comprising mostly solids and some liquids. For example, in FIG. 3A, two outputs of the solids

separator 106 are labeled as the green stream, which is the liquid portion, and the brown stream, which is the solids portion.

[0069] The frontend separation system 100 is configured to receive human waste from a user into a main vessel 102. The main vessel 102 can be configured based on a regional preference and/or customs. In some regions of the world, users are accustomed to a squat configuration toilet. In some regions of the world, users are accustomed to a pedestal or sitting configuration toilet. The main vessel 102 can be a toilet bowl configured for either a squat or pedestal configuration. Similarly, while the examples of combined waste herein include feces, urine, toilet paper, and/or flush water, in some regions of the world, it may not be customary to use toilet paper. For users that do not use toilet paper, frontend separation system 100 and the main vessel 102 can be adapted for a rinse configuration. In a rinse configuration, the excess rinse water can also be accommodated and can be considered as added to the combined waste instead of or in addition to the flush water.

[0070] The flush tank 104 can be configured to deliver a volume of flush water to the main vessel 102. In some examples, the volume of flush water is a predetermined amount regardless of the human waste event. In some examples, the predetermined amount of flush water is based on whether the human waste received is due to a urination event or a defecation event. The flush tank 104 can be configured to receive and store water from an external system or recirculated source for use as flush water. In one example, the water for the flush tank 104 can be received from another system or module of a toilet system that interconnects with the frontend separation system 100. For example, the water for the flush tank 104 can be received from the urine and wastewater treatment system 300. In another example, the water for the flush tank 104 can be received from a municipal water supply or other external water supply. The flush tank 104 can also be configured with an overflow outlet to divert excess water to the buffer tank separation system 200. The human waste collection and separation system can be configured with an overflow output from a flush tank 104.

[0071] The frontend separation system 100 can also include a controller 115. For example, the controller 115 can include a microprocessor and memory and be configured to control or operate one or more elements of the frontend separation system 100. The controller 115 can be CE compliant. The controller 115 can be configured initiate a flush sequence and to control or operate additional elements for the frontend separation system 100. For example, the controller

115 can operate the vacuum pump 112, main valve 116, and additional components not shown. For example, the frontend separation system 100 can also comprise valves, pumps, motors, sensors, and the like (not shown). The controller 115 can be configured to control or operate one or more valves, pumps, motors, and sensors based on an indication that user input has been received in the main vessel. For example, a sensor and/or input via the user interface panel 108 can control the operation of the vacuum pump 112 or other means to evacuate the main vessel 102. The waste from the main vessel 102 can be routed to the solids separator 106 by actuating the main valve 116. Additionally, the controller 115 can be configured to control the release of a separated liquids portion and/or separated solids portion in the vacuum tank.

[0072] As shown in FIG. 3A, a user interface panel 108 can be configured to initiate the release of a volume of flush water from the flush tank 104 into the main vessel 102. In some examples, the user interface panel 108 can include buttons or other selector options for the user to select a urination or defecation waste event to flush the toilet. For example, the selector options may include buttons, levers, switches, knobs, digital interfaces, and the like. For example, if the user deposits toilet paper during the urination event, the user can select a small flush button on the user interface panel 108 to release a first predetermined volume of water to and from the flush tank 104 to wash any residual urine and/or toilet paper and evacuate the contents of main vessel 102 to the frontend solids separator 106. Similarly, for a defecation event, the user can select a flush button on the user interface panel 108 to release a second predetermined volume of water to and from the flush tank 104 to wash the mixed waste contents and evacuate the main vessel 102 to the frontend solids separator 106. For example, the first predetermined volume of water can be a smaller amount for a urination event compared to a larger amount of the second predetermined volume of water for a defecation event.

[0073] In an example, the user interface panel 108 can have color coded buttons for identification by the user, but color is not necessary. For example, the buttons could include symbols and/or words. Further, a simplified panel may only include two buttons for a urination event and a defecation event. In a simplified example, the size of the button may indicate the type of event. For example, a smaller button may indicate a urination event to release a first predetermined volume of water, and a larger button may indicate a defecation event to release a second predetermined volume of water, which is a larger volume of water. The user interface panel 108 is not limited to the example configurations provided, as the buttons in the panel are

configured to activate a signal to the controller 115 to operate a flush sequence related to the waste event. For example, the user can select a flush button on the user interface panel 108 to select the type of waste event, such as a urination or defecation event. For a waste event that includes at least toilet paper, the contents of the main vessel 102 can be routed to the solids separator 106. For example, for a human waste event, the event flush button is pressed, flush water is introduced to the main vessel 102 from the flush tank 104 to wash a mixture of residual urine, residual feces, and/or toilet paper to the bottom of the main vessel 102, which is closed off by a main valve 116, which is a two-way valve. At this time, a weak vacuum can be generated in the solids separator 106 by activation of the vacuum pump 112. Once a predetermined vacuum pressure is achieved, the main valve 116 can be opened and the waste transported to into the solids separator 106.

[0074] In another example, the frontend separation system 100 can comprise at least one sensor configured to detect a waste event and send a signal to the controller 115 to control the flush operation to release water from the flush tank 104. In an example with at least one sensor, the user interface panel 108 can be optional, omitted, or serve as a backup secondary to the sensors. In some examples, the sensors can detect a urination or defecation event and release a first or a second predetermined volume of water accordingly.

[0075] In another example system, as shown in FIG. 3B, the alternate main vessel 122 can comprise a urine diverter 124 to provide an additional output stream comprising urine from the frontend separation system 101 (system 101). System 101 is substantially the same as frontend separation system 100 with a substitution of alternate main vessel 122 comprising a urine diverter 124, as well additional features to route the diverted urine stream, shown as the yellow stream in FIG. 3B. One example of a main vessel including a urine diverter is disclosed for example in PCT application No. PCT/AT2019/060064. The urine diverter can be shaped within the vessel and configured such that surface tension and cohesive effects allow the bypass portion of the liquid waste to follow the contour of the vessel to a bypass liquids outlet. With this optional feature of an alternate main vessel 122 comprising a urine diverter 124, the alternate main vessel 122 can be configured in either a squat or pedestal configuration and can be adapted for a rinse configuration, as specified for different regions of the world. The urine diverter 124 can be incorporated into the geometry of the toilet bowl design and configured to capture the urine in a passive manner. For example, a urination event or waste event comprising urine, the urine is in a liquid form, thus there

is no need to separate solids. When using the alternate main vessel 122 comprising a urine diverter 124, the urine can be separated from without the use of water via a urine diverter 124.

[0076] In some examples, the urine stream output shown as the yellow stream in FIG. 3B can be temporarily stored in a urine tank 126 or routed to join the liquid output stream from the solids separator 106 or routed treatment in another module or system. For example, a urine stream from the urine tank 126 can be directed to an auxiliary inlet of the buffer tank separation and homogenization system 200. In some examples, the yellow and green streams can be transported separately to other systems or treatment modules, or combined for transport, depending on the type of toilet or treatment system to which the frontend separation system 101 is connected. For example, if a treatment system can utilize or output the separated urine, the yellow and green streams can remain separate. In another example, the yellow and green streams can be combined and processed as a liquid waste stream.

[0077] As shown in FIG. 3B, the remaining features of system 101 are substantially the same as shown in frontend separation system 100 of FIG. 3A. For some urination events, at least a portion of the urine can be diverted or routed separately. As described with respect to frontend separation system 100, the user input received or remaining in the alternate main vessel 122 is combined with water with a flush event to form a combined waste that can be routed to the solids separator 106 by actuating the main valve 116. For example, a waste event that includes at least toilet paper, the mixed waste contents of the alternate main vessel 122 can be routed to the solids separator 106 by generating a weak vacuum in the solids separator 106 by activation of the vacuum pump 112. Once a predetermined vacuum pressure is achieved, the main valve 116 can be opened and the waste transported to into the solids separator 106.

[0078] The controller 115 can be configured to control or operate additional elements for the system 101. For example, the system 101 can also comprise valves, pumps, motors, sensors, and the like (not shown) to control and facilitate the operation of the system, including transporting urine from the urine tank 126. In some examples, a urine tank 126 can be included in the frontend separation system 101 having the alternate main vessel 122. A sensor can be positioned at the urine tank 126 to monitor the level of liquid in the urine tank. In some examples, a pump can be provided to facilitate the movement of the yellow stream from the urine tank 126 to an outlet of the frontend separation system 101.

[0079] Referring to FIGS. 4 and 5 an example of a frontend solids separator 106 is illustrated. As shown in FIG. 4, an example solids separator 106 includes a vacuum tank 130 having an inlet 132, a separating filter 134, a solids outlet 136, and a liquids outlet 138. The vacuum tank 130 can include a top portion 140, a base 142, and a cylindrical wall 144. The solids separator 106 can also include a first valve 146 and a first actuator 148 for the solids outlet 136 and a second valve 150 and a second actuator 152 for the liquids outlet 138. The first valve 146 and second valve 150 can be two-way valves.

[0080] In FIG. 5, a cross section of the vacuum tank 130 is shown. The vacuum tank 130 comprises an inlet chamber 156 formed within the vacuum tank 130 at the top portion 140. The inlet chamber 156 comprising the inlet 132 and a chamber outlet 158. A solids containment portion 160 is formed in the base 142 of the vacuum tank 130 and positioned centrally within the vacuum tank 130. The solids containment portion 160 includes the solids outlet 136. The solids containment portion 160 is configured to hold a separated solids volume of the combined waste that is controlled by the geometry. For example, the solids containment portion 160 can have a conical shape, with a first diameter (d_{s1}) substantially equal to the diameter of the separating filter 134 and a second diameter (d_{s2}) at the chamber outlet 158. For example, the diameters of 160 can vary and conical angle can vary between 0 degrees and 90 degrees to a control the volume of the separated solids in 160. A liquids containment portion 162 is formed in the base 142 of the vacuum tank 130 and contained within the vacuum tank 130 surrounding the solids containment portion 160. The liquids containment portion 162 includes a liquids outlet 138. The liquids containment portion 162 is configured to hold a separated liquid portion of the combined waste portion. The separating filter 134 having a cylindrical tubular shape and extending from the chamber outlet 158 to the solids containment portion 160. The separating filter 134 forming a central separation volume 164 within the vacuum tank 130.

[0081] The inlet chamber 156 is configured to receive the combined waste via the inlet 132 and to direct the combined waste to the central separation volume 164. The liquid portion of the combined waste is allowed to flow through the separating filter 134 to an outer portion 166 surrounding the central separation volume 164 and collects in the liquids containment portion 162 of the base 142. The solids portion of the combined waste is contained within the central separation volume 164 and collected in the solids containment portion 160 of the base 142. The solids containment portion 160 can have funnel or conical shape to direct the solids portion of the

combined waste to the solids outlet 136. As will be further described, the solids portion collected in the solids containment portion 160 can be released via solids outlet 136 by actuating the first valve 146. The base 142 of the vacuum tank 130 has an inclined base within the liquids containment portion 162 such that a flow of the liquid portion of the combined waste collected in the liquids containment portion 162 is directed to the liquids outlet 138 by gravity. The liquid portion collected in the liquids containment portion 162 can be released via liquids outlet 138 by actuating the second valve 150.

[0082] The separating filter 134 can comprise profile wires 168 mounted on supports 170 and aligned to form slots 172 (FIG. 6) configured to retain solids in the central separation volume 164 and allow liquids to pass through to the outer portion 166 of the vacuum tank 130. The profile wires 169 can be rods formed with a specified profile cross section. In an example, each profile wire can have cross section with a wedge shape. In other examples, the profile wire can have a circular, rectangular, triangular, or other specified shape. The separating filter 134 can be configured with the profile wires 168 spaced with to for slots with a predetermined minimum width (w_1) on at least one side. The size and shape of the slots may vary based on the configuration. For example, the profile wires 168 can be arranged to form slots 172 between the profile wires 168, such that if the arrangement is flat, the slots have a predetermined minimum width (w_1) on at least one side of the arrangement.

[0083] In the example shown in FIGS. 4 and 5, the supports 170 are oriented in a direction substantially parallel to the central axis (X) of the vacuum tank 130, and the profile wires 168 of the separating filter 134 are oriented in a substantially horizontal direction, such that the slots 172 between the profile wires 168 are oriented in a direction substantially perpendicular to the central axis (X) of the vacuum tank 130. In another example (not shown), the profile wires 168 of the separating filter 134 are oriented in a direction substantially parallel to the central axis (X) of the vacuum tank 130, such that the slots between the profile wires 168 are oriented in a direction substantially parallel to the central axis of the vacuum tank 130.

[0084] In FIG. 6, a portion of the separating filter 134 is shown to illustrate the liquid separation of the combined waste in greater detail. In one example, the separating filter 134 can be a wedge wire filter, although the design can be implemented and relied upon in other types and configurations of metal or wire filters. In this example, the separating filter 134 comprises a plurality of profile wires 168, each of the profile wires having a wedge shape or triangular cross-

section. The plurality of profile wires 168 can be arranged at a regular interval to form a plurality of grooves extending from slits between the profile wires at an inner circumference of the cylindrical tubular shape of the separating filter 134 to wider openings at an outer circumference of the cylindrical tubular shape. For example, the plurality of profile wires 168 can be wedge wires and arranged such that the separating filter 134 has V-shaped grooves extending from slots with a predetermined minimum width (w_1) between the wedge wires at an inner circumference of the cylindrical tubular shape at the central separation volume 164 to wider openings (w_2) at an outer circumference of the cylindrical tubular shape at the outer portion 166. The shape of the profile wires allowing the liquid to pass while the solids are contained within the central separation volume 164 and directed to the solids containment portion 160 in the base 142 of the vacuum tank 130. For example, the controller 115 can also actuate pumps, motors, and valves to control of the vacuum tank 130. The controller 115 can actuate the vacuum pump 112 to evacuate the combined waste from the main vessel 102 or alternate main vessel 122 into the inlet chamber 156 via the inlet 132. The inlet 132 and inlet chamber 156 are configured such that when the combined waste stream enters the inlet chamber 156, the velocity of combined waste stream is slowed by the geometry of the inlet chamber 156 such that the combined waste stream is guided in a spiral to the central separation volume 164 of the vacuum tank 130. The fluids can pass through the separating filter 134 and collect in the liquids containment portion 162 of the base 142.

[0085] For a urination event, the proportionally small amount of solids can collect in the solids containment portion 160; however, the solids can remain collected until a subsequent event with additional solids. For example, if a urination event is determined by user selection or a sensor, the controller 115 can actuate the second valve 150 to release the collected liquids via the liquids outlet 138.

[0086] For a defecation event, where a solids portion is collected in the solids containment portion 160 in the base 142 of the vacuum tank 130, an overpressure can be applied to the vacuum tank 130 such that some remaining liquids within the separation volume are forced under pressure through the separating filter to collect in the liquids containment portion 162 of the base 142. The same vacuum pump 112 can be reversed for overpressure or separate pumps can be used to pressurize the content of the vacuum tank 130. The solids portion of the combined waste collected in the solids containment portion 160 can be released via the solids outlet 136 after a pressure is applied to the vacuum tank. A first actuator 148 can be configured to operate a first valve at the

solids outlet 136 and a second actuator 152 can be configured to operate a second valve 150 at the liquids outlet 138. The controller can be configured to open the first valve 146 when an overpressure is applied to the vacuum tank 130, releasing the solids portion of the combined waste collected in the solids containment portion 160. The second valve 150 can be actuated after the first valve 146, releasing the liquid portion of the combined waste collected in the liquids containment portion 162. The liquid portion of the combined waste collected in the liquids containment portion 162 can be released via the liquids outlet 138 by flow due to gravity after opening the second valve 150.

[0087] The solids separator 106 is configured with a first valve 146 at the solids outlet 136 that is actuated by a motor. In another example, the first valve 146 can be actuated by an overpressure. For example, the first valve 146 can be a ball valve. As the contents of the vacuum tank are pressurized, the first valve can be opened to direct the solids stream for treatment of the feces and other solids in one or more modules of water oxidation non-sewered single unit toilet system 10. For example, the solids stream output can be delivered as the input into a water oxidation solids treatment system 400. After the pressurization of the vacuum tank and release of the solids portion, the liquid portion can be released by opening the two-way valve. The liquid portions are allowed to passively drain from the liquid containment portion. The base of the liquid containment portion having an incline to direct the liquid to the liquids outlet 138. The liquid stream released from the liquids outlet 138 can be directed for treatment in one or more modules of water oxidation non-sewered single unit toilet system 10. For example, the liquid stream output can be delivered as the input into the urine and wastewater treatment system 300. For example, the liquid stream can be directed to a buffer tank separation system 200 and/or the urine and wastewater treatment system 300. In an example, the liquid portion separated from the combined waste comprises less than 5% dry solids content, the solid content comprising feces and toilet paper. In an example, the solids portion separated from the combined waste comprises about 1%-25% dry solids content, the solid content comprising feces and toilet paper.

[0088] The frontend can also include a touchless human machine interface configured to communicate the status of the toilet system to the user. For example, the human machine interface can be integrated into the user interface pane and can indicate that the toilet system is ready to use, requires maintenance, is shutdown, etc. The frontend separation system can be connected to a power source and, in some examples, can also include a backup battery in the case of intermittent

power or temporary power loss. In some examples, the frontend separation system 100 or complete toilet system 10 can be powered by a battery or off-grid energy systems.

[0089] FIG. 7 shows an example method for collection and separation of human waste using the frontend separation system 100 of FIG. 3A as described herein. At box 1102, receive a human waste into a vessel. The human waste comprises at least one of a liquid waste and a solids waste. The liquid waste comprises at least one of: urine and water. The solids waste comprises at least one of: feces and toilet incidentals, such as toilet paper.

[0090] In some examples, when the vessel includes a urine diverter 124, such as system 101 as shown in FIG. 3B, the method can also include diverting a bypass portion of the urine via a urine diverter formed in the vessel. For example, the bypass liquids outlet can be connected to a urine tank 126 to hold the liquid containing mostly urine before releasing a yellow stream for further treatment. For example, for a urination event, the liquid waste can comprise mostly urine and some water and be diverted from the main vessel outlet 114 via the urine diverter 126 to a yellow stream outlet.

[0091] At box 1104, receive a volume of flush water for a human waste event sufficient to wash any residual urine, residual feces, and toilet paper to the main outlet of the main vessel. In some examples, a predetermined volume of water is used for any human waste event. In some examples, a first predetermined volume can be used for a urination event and a second predetermined volume can be used for a defecation event. For example, the first predetermined volume can be considered small, relative to the volume of water needed for a defecation event.

[0092] At box 1106, evacuate the combined waste, including the flush water, via the main outlet of the main vessel. A vacuum pump can be used to form a weak vacuum to transport the combined waste to a vacuum tank of the solids separator.

[0093] At box 1108, receive the combined waste into the inlet portion of a vacuum tank of a solids separator. The inlet portion can be shaped to decelerate and direct the combined waste into a separation volume within the vacuum tank. The inlet to the solids separator can be positioned to receive the combined waste tangentially and direct the combined waste along a circumferential interior wall of the inlet chamber to decelerate and damper the input. For example, the inlet can be positioned off center, such that the combined waste stream received flows in along the interior wall inlet chamber, and in a circular motion through the inlet chamber, where the chamber is

shaped to guide the combined waste stream to the chamber outlet. For example, the inlet is off set from the center and formed such that the input stream is guided in a spiral.

[0094] At box 1110, separate a liquids portion of the combined waste through the separating filter to collect the liquids portion in a liquid containment portion of the base. The base can have a solids containment portion formed in the base of the vacuum tank and positioned centrally within the vacuum tank and a liquid containment portion formed in the base and surrounding the solids containment portion. As the combined waste stream is received into the separation volume within the separating filter, some of the liquid having lateral directional motion will pass through the separating filter. The liquid of combined waste received into the separation volume can also be directed to flow through the separating filter by gravity.

[0095] At box 1112, collect the solids portion of the combined waste in the solids containment portion of the base. The solids containment volume can be configured to hold a separated solids portion of the combined waste as the liquid portions pass through to a volume between the separating filter and the vacuum tank wall. The solids portion of the combined waste can remain within the separating filter as the combined waste settles by gravity. The solids containment portion can have a funnel shape to contain and direct the solids to the solids outlet 136, while allowing excess liquid to collect in the liquid containment portion.

[0096] At box 1114, release a liquid portion of the combined waste that has collected in the liquid containment portion formed in the base of the vacuum tank. The solids separator configured with a two-way valve at the liquids outlet 138 can be operated by an actuator. liquid portion can be released by opening the two-way valve. The liquid portion is allowed to passively drain from the liquid containment portion. The base of the liquid containment portion can have an incline to direct the liquid to the liquids outlet 138. The liquid stream released from the liquids outlet 138 can be directed for treatment in the buffer separation system 200. For example, the liquid stream output can be delivered as the input the buffer separation system 200.

[0097] At box 1116, release the solids portion of the combined waste that has collected in the solids containment portion via the solids outlet 136. The solids can be released with overpressure or with gravity only. When the evacuation of the vacuum tank is done by overpressure, the liquid needs to be drained before overpressure is applied. An overpressure can be applied to the vacuum tank such that some remaining liquids within the separation volume are forced with air through the separating filter to collect in the liquid containment portion of the base. The solids separator

is configured with a two-way valve at the solids outlet 136 that is actuated by a motor. As the contents of the vacuum tank are pressurized, the two-way valve can be opened to direct the solids stream for treatment in the water oxidation solids treatment system 400. For example, the solids stream output can be delivered as the input into the water oxidation solids treatment system 400.

[0098] BUFFER TANK SEPARATION AND HOMOGENIZATION SYSTEM

[0099] Next, in FIGS. 8-13D the buffer tank separation and homogenization system 200 of the water oxidation non-sewered single unit toilet system 10 is shown in greater detail. The buffer tank separation and homogenization system 200 can be a dual chamber tank system for the short-term storage and fractional passive separation of liquid from solid human waste and toilet paper. The buffer tank separation and homogenization system 200 can be connected to a homogenization component that macerates the solid waste to a uniform particle size and transports the slurry to the water oxidation solids treatment system 400. The buffer tank separation and homogenization system 200 can receive at least one input and produce at least two outputs that can be delivered separately for further treatment. For example, at least one input stream can be received into the buffer tank separation and homogenization system 200 from a frontend unit that collects and separates a mixed waste. In an example, the frontend separation system 100 can deliver a green stream and a brown stream. In some examples, the frontend separation system 100 can deliver a green stream, a brown stream, and a yellow stream. A green stream, comprising primarily urine, flush water and toilet paper can be delivered to a liquids tank or “green tank” and a brown stream, comprising a mixture of feces, urine, flush water and toilet paper can be delivered to a solids tank or “brown tank.” It is noted that the yellow, green, and brown streams are defined by the composition of human waste, as described herein, not by the actual color of the physical stream. Similarly, the liquids tank and the solids tank can contain both liquids and solids. The output from the liquids tank can be delivered to the urine and wastewater system 300 for removal or destruction of pathogens or contaminants to produce usable water. The output from the solids tank can be delivered to the water oxidation solids treatment system 400 for removal or destruction of pathogens or contaminants to produce inert material output.

[00100] The buffer tank separation and homogenization system 200 can include a mechanism to separate and deliver the solid toilet paper from the green stream to the solids tank and the liquids from the brown stream to the liquids tank. Further, in some examples, the buffer tank separation and homogenization system 200 can receive a yellow stream from the frontend separation system

100. Additionally, recirculation input streams can be received into the buffer tank separation and homogenization system 200. For example, a filter concentrate can be received from the urine and wastewater treatment system 300 and a liquid effluent can be received from the water oxidation solids treatment system 400 for further processing.

[00101] The primary output streams from the buffer tank separation and homogenization system 200 are a collected liquids stream and a collected solids slurry. The collected solids or “brown” slurry or feces slurry can comprise feces, flush water, toilet paper and urine. A homogenizer, similar in design and operation to a bladed macerator, can be used to transform the collected solids output in the solids tank into a uniform and homogenized slurry for transport to the treatment modules. In some examples, the homogenizer can be incorporated into the solids tank design. The brown slurry can be delivered to the water oxidation solids treatment system 400. The liquid effluent or collected liquids from the liquids tank can be pumped from the liquids tank to a urine and wastewater treatment system 300 and can comprise urine, flush water, and trace amounts of toilet paper or other solids.

[00102] FIG. 8 illustrates an example diagram of the buffer tank separation and homogenization system 200. The buffer tank separation and homogenization system 200 can include a belt separator 204, a liquids tank 206, a solids tank 208, and a homogenizer 210. The input stream can be at least one input stream comprising liquids and/or solids and received via at least one inlet. The buffer tank separation and homogenization system 200 can be used receive and separate an input stream of human waste into a solids portion delivered to a solids tank 208 and a liquids portion delivered to a liquids tank 206. The solids tank 208 can contain some liquids and the liquids tank 206 can contain some solids. In each of the liquids tank and solids tank, the solids are separated from the liquids by sedimentation. A liquids output from the liquids tank 206 can be directed for further processing. For example, the liquid effluent from the liquids tank can be a liquids output pumped from the liquids tank to the urine and wastewater treatment system 300. The settled solids in the liquids tank 206 can be removed and/or redirected as an additional input stream to the buffer tank separation and homogenization system 200. The solids output from the solids tank 208 can be directed for further processing. For example, the solids output can be received into a homogenizer 210 to produce a feces slurry delivered to a feces or solids treatment system. A liquid overflow from the solids tank 208 can be removed and/or redirected as an additional input stream to the buffer tank separation and homogenization system 200. The buffer

tank separation and homogenization system 200 can also include a controller 215 comprising a processor and memory and configured to operate the belt separator 204 as well as other sensors, valves, actuators, motors, and pumps not shown.

[00103] Shown in FIGS. 9A-9C are bottom, front, and cross-sectional views of the belt separator 204 of the buffer tank separation and homogenization system 200. The belt separator 204 can comprise a perforated belt 214 looped between two rollers 216a, 216b and driven by a motor 218. The belt separator 204 can be positioned to receive an input stream via at least one inlet onto the perforated belt 214 of the belt separator 204. The perforated belt 214 of the belt separator 204 can comprise pores (not shown) configured to allow the liquids portion of the input stream to pass through the perforated belt 214 to the liquids tank 206 and to retain the solids portion on the perforated belt 214. The perforated belt 214 can convey the retained solids toward a scraper or squeegee 220 configured to remove the solids from the perforated belt 214 and direct the solids to the solids tank 208. For example, the perforated belt 214 looped between the two rollers 216a, 216b can be driven at a first end 222 of the belt separator 204 by the motor 218 turning a drive wheel or gear 226 connected to a first roller 216a, with the scraper or squeegee 220 can be positioned at the second end 224. A splash shield 228 can be positioned laterally on both sides of the perforated belt 214, extending at least partially between the first and second ends 222, 224, and configured to direct the at least one input onto the perforated belt 214 such that the solids are also retained on the perforated belt 214.

[00104] The buffer tank separation and homogenization system 200 can receive at least one input stream onto the belt separator 204 via at least one inlet. As shown in FIGS. 9B and 9C, an example buffer tank separation and homogenization system 200 can have individual inlets configured to receive individual ones of the at least one input stream. For example, the individual inlets can be configured for the volume, pressure, flow velocity, and/or expected solids content of the individual input streams of the at least one input stream. For example, the buffer tank separation and homogenization system 200 can comprise a first inlet 230 configured to receive a mostly liquids input, a second inlet 232 configured to receive a mostly solids input, and optionally one or more auxiliary inlets 234 to receive other input streams. For example, the buffer tank separation and homogenization system can include one or more auxiliary inlets 234 configured to receive at least one of: a diverted urine stream, a sludge stream received from a liquids collection tank, an overflow stream received from a solids collection tank, a reject stream received from a

liquids treatment system, a filtrate received from a feces treatment system, and a condensed effluent received from a feces treatment system.

[00105] For example, the buffer tank separation and homogenization system 200 can receive a green stream and a brown stream, separately, as two input streams onto a perforated belt 214 of the belt separator 204. The belt separator 204 of buffer tank separation and homogenization system 200 can separate and deliver the solid toilet paper from the green stream to the solids tank and the liquids from the brown stream to the liquids tank. For example, the mostly liquids input stream can be received via a first inlet 230 at a different flow velocity than the mostly solids input stream comprising feces received via a second inlet 232. The second inlet 232 can be configured to receive the mostly solids input stream, having a large solids content, can be delivered under pressure and/or at a high flow velocity, as such the second inlet can be configured to slow the flow velocity as the mostly solids input stream is received. In some examples, the mostly solids stream can be delivered to the buffer tank separation and homogenization system 200 under pressure. The second inlet 232 can comprise an offset chamber inlet 236, an inlet chamber 238 having an interior wall surface 240, and a chamber outlet 242. The second inlet 232 can be configured receive the mostly solids input stream via the offset chamber inlet 236, direct the input stream toward an interior wall surface 240 of the inlet chamber 238 to flow out the chamber outlet 242 onto a perforated belt 214 of the belt separator 204.

[00106] FIGS. 10 and 11 show an example buffer tank separation and homogenization system 200 in greater detail. As shown, the belt separator of FIGS. 9A-9C is secured to a dual chamber enclosure 248. FIG. 11 illustrates a cross-section of the buffer tank separation and homogenization system of FIG. 10. As shown in FIG. 10, a liquids tank 206 and a solids tank 208 are chambers within the enclosure and positioned beneath the belt separator 204. As shown in FIG. 10, the liquids tank 206 includes a liquids tank outlet 252 and a sludge outlet 254. The solids tank 208 includes a solids tank outlet 256 and a recirculation outlet 258. The settled solids output within the solids tank 208 can be routed to the macerator 260 attached to the solids tank outlet 256 so that a uniform feces slurry can be formed. For example, the macerator 260 can be a homogenizer 210, as described herein. The slurry from the macerator 260 can be directed to a feces treatment system via the solids system outlet 262. In some examples, a portion of the contents of the solids tank 208 can also be routed for recirculation via the recirculation outlet 258. The output from the solids tank can be recirculated to the solids tank 208 via recirculation outlet 258. The buffer tank

separation and homogenization system 200 can also include a bypass 270 for overflow or circulation of the solids tank 208, where the flow and pressure are adjustable. Additionally, when integrated with other systems such as a urine and wastewater treatment system and/or a feces treatment system liquid portions containing solids, such as filtrate, condensed effluent, and/or filter reject, can be received as input streams for further processing via one or more auxiliary inlets 234.

[00107] Illustrated in FIG. 11 is a cross-sectional view of an example buffer tank separation and homogenization system 200. The buffer tank separation and homogenization system 200 can include the belt separator 204, a liquids tank 206, and a solids tank 208. In this example, the liquids tank 206 and the solids tank 208 are chambers contained within the same dual chamber enclosure 248, although the design can be implemented and relied upon in other configurations such as physically separate tanks. In this example, the belt separator 204 is positioned above a portion of the liquids tank 206 and a portion of the solids tank 208 and is configured to receive an input stream from the first inlet 230, the second inlet 232, or an individual one of the plurality of auxiliary inlets 234 onto the perforated belt 214. A liquid portion of the input stream can flow by gravity into the liquids tank 206. A solids portion of the input stream can be conveyed by the moving perforated belt 214 towards the solids tank 208. A scraper or squeegee 220 can be positioned at the second end 224 of the belt separator 204 and configured to remove solids from the moving perforated belt 214. A liquid deflector 264 can be positioned beneath the second end 224 of the belt separator 204 to capture and channel liquids to the liquids tank 206 as the solids are removed from the perforated belt 214 or liquids received onto the perforated belt 214 that flow toward the second end 224.

[00108] The liquids tank 206 is configured to clarify the fluids received by allowing solid particles to settle. In some examples, the liquids tank 206 can include a bottom wall 266 inserted into the liquids tank 206 or formed in the body of the liquids tank 206. The bottom wall 266 can be angled or shaped to direct a sludge of the settled solids to a sludge outlet 254. In an example, a sludge stream of settled solids can be delivered to the belt separator 204 to remove any liquid content and direct the solids to the solids tank 208. In another example, the settled solids can be delivered directly to the solids tank 208. A clarified liquid stream can be released via a liquids tank outlet 252. The liquids tank 206 can also include a baffle or weir (not shown) to help reduce the number of particulates that enter the liquids tank outlet 252. In an example, the clarified liquid stream output can be released via natural overflow. In another example, the clarified liquid stream

output can be released via a valve system or pumped. For example, the clarified liquid stream output can be delivered to a urine and wastewater treatment system 300.

[00109] The solids tank 208 is configured to receive solids separated by the belt separator 204 and to allow solid particles to settle and extract liquids. In some examples, the solids tank 208 can include a bottom wall 268 inserted into the solids tank 208 or formed in the body of the solids tank 208. The bottom wall 268 can be angled or shaped to direct the settled solids to the solids tank outlet 256. The solids tank outlet 256 is connected to a homogenizer 210 configured to mix, grind, or macerate the settled solids from the solids tank 208 to a slurry that can be delivered from the buffer tank separation and homogenization system 200 and transported to a feces treatment system for removal of pathogens. The buffer tank separation and homogenization system 200 can also include a bypass 270 (FIG. 10) for overflow or circulation of the solids tank 208, where the flow and pressure are adjustable. In some examples, the liquid phase separated from the solids can be recirculated as input through an auxiliary inlet 234 and received as an input onto the belt separator 204.

[00110] The buffer tank separation and homogenization system 200 can also comprise additional valves, sensors, switches, actuators, pumps, and the like to facilitate the operation of the buffer tank separation and homogenization system 200. Further, the buffer tank separation and homogenization system 200 can comprise a controller to operate at least the valves, sensors, switches, actuators, and pumps of the system. The buffer tank separation and homogenization system 200 can also include vent outlets for one or more of the tanks described herein. For example, the solids tank 208 can have an air exhaust vent 272 (FIG. 10). Each vent outlet can be connected to a main gas exhaust line with a gas filter. For example, when the buffer tank separation and homogenization system 200 is a module in a single unit toilet system, the main exhaust line can also receive gas vented from other modules of the single unit toilet system. The gas filter can be configured so that the filtered gas release from the system is ISO 30500 compliant.

[00111] FIG. 12 shows an example method for buffer tank separation and homogenization as described herein. Although the method shown provides an example for producing an output for both the liquids tank and solids tank, steps can be added, omitted, or performed in a different sequence. For example, a single input stream can comprise a solids portion and a liquids portion. The method for processing the solids portion and liquids portions are shown separately, as liquids

and solids outputs are processed in separate tanks, but the steps may occur simultaneously or in some other sequence.

[00112] At box 1202, the method can include receiving, onto a belt separator, an input stream comprising at least one of: solids and liquids. The buffer tank separation and homogenization system 200 can receive one or more input streams from separate sources. For example, a first input can be considered the green stream, as described herein, comprising mostly liquid with some solids, for example, toilet paper. In an example, a second input comprising at least feces and water can also be received separately via a second inlet. The second input can be considered the brown stream, as described herein, containing solids. For example, the second input can include feces, toilet paper, urine, and/or water. In some examples, a urine stream or yellow stream can be received via an auxiliary inlet. Although the urine stream is primarily urine, some trace amounts of toilet paper or other solids, if present, can be captured by the belt separator. As previously discussed, additional input streams can be received via one or more of the auxiliary inlets including: a sludge stream received from the liquids collection tank, an overflow stream received from the solids collection tank, a reject stream received from a liquids treatment system, a filtrate received from a feces treatment system, and a condensed effluent received from a feces treatment system. More than one input stream can be received separately or simultaneously.

[00113] At box 1204, the method can include separating, by the belt separator, the input stream into a solids portion and a liquids portion. For example, the toilet paper and other solids can be removed from an input stream that is mostly liquid with some solids. Similarly, the liquids can be removed from an input stream that is mostly solids with some liquids. The perforated belt of the belt separator can comprise pores configured to allow the liquids portion of the input stream to pass through to the liquids collection tank and to retain the solids portion on the perforated belt.

[00114] At box 1206, the method can include delivering the liquids portion to a liquids tank for sedimentation. The liquids portion of the input stream is allowed to pass through to the liquids collection tank. In some examples, at least some of the liquids portion of the input stream is directed to the liquids collection tank via a liquid deflector positioned beneath the belt separator.

[00115] At box 1208, the method can include separating, by sedimentation, at least a collected liquids portion and a sludge of settled solids. In the liquids collection tank, the solids are allowed to settle to the bottom of the liquids tank forming a collected liquids portion and a sludge. The

liquids tank can include or be formed with a bottom wall that directs the separated solids toward a sludge outlet.

[00116] At box 1210, the method can include releasing a collected liquids portion from the liquids collection tank. In an example, the collected liquids portion output can be released natural overflow. In another example, the collected liquids portion output can be released via a valve system. For example, the collected liquids portion output can be delivered to a urine and wastewater treatment system. In some examples, the method can also include receiving a concentrate from a urine and wastewater treatment system via an auxiliary inlet. In some examples, at box 1212, the method can also include delivering, periodically, at least a portion of the contents of the liquids collection tank to the belt separator. For example, the sludge portion of the liquids collection tank can be delivered to the belt separator via an auxiliary port.

[00117] At box 1214, the method can include delivering the solids portion to a solids tank for sedimentation. The solids portion of the input stream can be retained on the perforated belt and conveyed to the solids collection tank. In some examples, at least some of the solids portion of the input stream can be removed from the belt using a stationary squeegee that scrapes the retained solids from the belt. For example, the solids portion can comprise feces and/or toilet paper from at least one input stream.

[00118] At box 1216, the method can include separating, by sedimentation, contents of the solids collection tank into at least a concentrated solids portion. The feces, toilet paper, and other solid particles can settle to the bottom of the solids collection tank, forming a concentrated solids portion.

[00119] At box 1218, the method can include delivering the concentrated solids portion to a homogenizer to form a slurry. The homogenizer can be a bladed macerator configured to transform the collected solids output in the solids tank into a uniform and homogenized slurry for transport to the treatment modules.

[00120] At box 1220, the method can include releasing the slurry output. For example, the slurry can be delivered to the slurry output to feces treatment system for further processing and removal or destruction of pathogens or contaminants. In some examples, the method can also include receiving a liquid effluent from a feces treatment system via an auxiliary inlet to the belt separator for separation. In some examples, at box 1222, the method can also include delivering,

periodically, at least a portion of the contents of the solids collection tank to the belt separator or recirculating a portion of the solids tank via another inlet.

[00121] FIGS. 13A-13D further illustrate the operation of the buffer tank separation and homogenization system 200 by illustrating the flow within the system based on different waste events. The waste events can be determined by a user or detected by a sensor or simply directed to predetermined inlets of the buffer tank separation and homogenization system 200. As described herein, a green stream can be mostly liquid with some solids, a brown stream can be mostly feces and can also be mixed with other liquid and solid waste, and a yellow stream can be primarily urine.

[00122] Shown in FIG. 13A, for a urination event, a green stream can be received onto the belt separator 204 as the input stream. In some examples, a yellow stream can be received onto the belt separator 204. The liquids are delivered to the liquids tank 206 by passing through the perforated belt. As much toilet paper as possible is removed from the input stream by the belt separator 204 and delivered to the solids tank 208. After the solids have settled from the contents of the liquids tank, a collected liquids portion can be released. The liquids tank 206 can include a baffle or weir to help reduce the number of particulates that enter the liquids tank outlet 252.

[00123] In FIG. 13B, for a defecation event, a brown stream comprising feces, toilet paper, some urine, and some water can be received as the input stream. The liquids from the brown stream can be delivered through the perforated belt to the liquids tank 206. The solids from the brown stream can be delivered to the solids tank 208. The collected solids output can be delivered to the homogenizer and then to a feces treatment system for further processing.

[00124] FIG. 13C. illustrates an example of recirculating the contents of the liquids tank 206. There can be a buildup of solids in the liquids tank 206. Periodically, the sludge settled solids of the liquids tank 206 can be recirculated to the top of the belt separator 204 for a separation loop. For example, the liquids tank 206 can be recirculated about 2-3 times a day. The recirculation can improve the solid/liquid separation and prevent stagnation in the liquids tank 206.

[00125] FIG. 13D illustrates an example of a similar recirculation process for the solids tank 208. There can be a buildup of solids in the solids tank 208. Periodically, a portion of the contents of the solids tank 208 can be recirculated to the top of the belt separator 204 for a separation loop. For example, the solids tank 208 can be recirculated every 1-2 days. The recirculation can improve the solid/liquid separation and prevent stagnation in the solids tank 208.

[00126] URINE AND WASTEWATER TREATMENT SYSTEM

[00127] FIGS. 14 and 15 illustrate the urine and wastewater treatment system 300 of the water oxidation non-sewered single unit toilet system 10. As shown in FIG. 14, the urine and wastewater treatment system 300 can comprise an ultra-filtration (UF) stage comprising an ultra-filtration (UF) membrane filter 304 and a reverse osmosis (RO) stage comprising a reverse osmosis (RO) membrane filter 312. The UF stage can also include a diffuser 322 positioned at an inlet 303 to the UF membrane filter 304, a permeate pump 306, and a reservoir tank 308. An air blower 314 can be connected to the diffuser 322 and configured to introduce air into fluid as it is received into the UF membrane filter 304. The RO stage can also include a high-pressure pump 310 and a permeate tank 316. Additionally, the reservoir tank 308 can receive RO concentrate from the RO stage and a concentrate tank 318 can be in fluid connection with the reservoir tank 308.

[00128] A buffer tank 302 can optionally be included in the urine and wastewater treatment system 300 and be configured to receive and hold liquid waste to be treated. Alternatively, the buffer tank 302 can be omitted and an external tank or buffer tank system that receives urine and/or wastewater can serve as the feed for the UF. For example, the urine and wastewater treatment system 300 can be connected to a liquids buffer tank 206 in a buffer tank separation and homogenization system.

[00129] In an example, the urine containing stream can be a green stream, as described herein, that comprises mostly urine, but can also include water and/or some trace solids, such as toilet paper. In some examples, the green stream can be processed prior to being received by the urine and wastewater treatment system 300. For example, a buffer tank separation and homogenization system can collect and reduce the solids in a human waste stream from a frontend user receptacle or other urine containing streams to clarify the liquid by separating at least a portion of solid particles. For example, the buffer tank 302 can be a liquids tank 206 of a buffer tank separation and homogenization system 200. For example, the liquids tank outlet 252 of the buffer tank separation and homogenization system 200 can be in fluid connection with the to the inlet 303 of the UF filter via a diffuser 322.

[00130] The UF membrane filter 304 can be in fluid connection with the buffer tank 302, for example via the diffuser 322. The liquid waste can receive into the UF membrane filter 304 such that an air blower 314 introduces air into the liquid via the diffuser 322 before it passes over the UF membrane filter 304. Mixing the air and liquid reduces the density of the liquid and displaces

the liquid upward, generating crossflow over the UF membrane filter 304 to separate a first permeate stream and a first concentrate stream. For example, the fluid mixed with air reduces the density of the fluid and displaces it upwards generating cross flow through the filter forming the UF permeate. The fluid that does not pass through the filter is the UF concentrate.

[00131] A permeate pump 306 can deliver the UF permeate stream, also called the first permeate stream herein, to a reservoir tank 308. The UF concentrate stream, also called a first concentrate stream herein, can be released as an output. For example, the UF concentrate can be delivered to the buffer tank 302. In some examples, if the urine and wastewater treatment system 300 is fluidically connected to the buffer tank separation system 200, the first concentrate stream can be delivered to the buffer tank separation system 200.

[00132] As shown in FIG. 14, the reservoir tank 308 can receive the first permeate of the UF membrane filter 304 via the permeate pump 306, which are all fluidically connected. A high-pressure pump 310 can transport the fluid from the reservoir tank through a RO membrane filter 312 at a high pressure to separate a second permeate stream and a second concentrate stream. In an example, the second concentrate stream, also called the RO concentrate herein, can be returned to the reservoir tank 308. In some examples, a portion of the second concentrate can be recirculated through the RO membrane filter 312. The majority of the second concentrate stream can be directed to a concentrate tank 318. The second permeate stream, also called the RO permeate herein, can be considered clean and/or usable water. The second permeate stream can be directed to a permeate tank 316 for holding and/or directed for use in a flush tank or discharged to another system or the environment. For example, the second permeate stream can be ISO 30500 compliant to be safely discharged into the environment.

[00133] The buffer tank 302, or liquids tank from another system, can be fluidically connected to the UF membrane filter 304 via a conduit such as tubing or other means. The UF membrane filter 304 can operate at a low pressure. For example, the liquid stream between the buffer tank 302 and the UF membrane filter 304 can be a low-pressure stream, having a pressure of about atmospheric pressure or about 1 atm and having a temperature of about 20-40°C. An air pump or air blower 314 can be positioned to introduce air to the fluid flow of the liquid stream at the feed to the UF membrane filter 304. For example, the air blower 314 can diffuse air into the liquid stream using diffuser 322, such as an air stone. The UF membrane filter 304 can separate fluid received into a first permeate and a first concentrate, where the first permeate is the portion of fluid

that passes through the UF membrane filter 304 and the first concentrate is the fluid rejected by the UF membrane filter 304. In some examples, if the urine and wastewater treatment system 300 is fluidically connected to a buffer tank separation system 200 and processed with the other fluids.

[00134] A permeate pump 306 can deliver the first permeate to a reservoir tank 308 at a low pressure. A high-pressure pump 310 can be fluidically connected between the reservoir tank 308 and the RO membrane filter 312. The high-pressure pump 310 can be configured to output a fluid at a higher pressure than the intake. For example, the high-pressure pump 310 can pump the first permeate from the reservoir tank at a low pressure, then deliver the fluid to the RO membrane filter 312 at a high pressure. For example, the low pressure can be about 1 bar and the high pressure can be about 30-35 bar. In some examples, a relief valve 324 can be positioned in the high-pressure conduit to return a portion of the pressurized first permeate liquid stream to the reservoir tank 308. The high-pressure pump 310 can deliver the first permeate liquid stream to the RO membrane filter 312 at a high pressure. For example, the high-pressure fluid feed to the RO membrane filter 312 can be about 435 psi and having a temperature of about 20-40°C. The RO membrane filter 312 can separate fluid received into a second permeate and a second concentrate, where the second permeate is the portion of fluid that passes through the RO membrane filter 312 and the second concentrate is the fluid rejected by the RO membrane filter 312. The RO membrane filter 312 can be fluidically connected to a permeate tank 316 configured to receive the second permeate. The RO membrane filter 312 can be fluidically connected to a concentrate tank 318 configured to receive the second concentrate. The second permeate stream can be directed to a permeate tank 316 for holding and/or directed for use in a flush tank or discharged to another system or the environment. For example, the second permeate stream can be ISO 30500 compliant to be safely discharged into the environment. The second concentrate stream can be returned to the reservoir tank 308 and a portion can be recirculated by the high-pressure pump 310 through the RO membrane filter 312.

[00135] The concentrate tank 318 can hold the RO concentrate delivered from the reservoir tank 308. At least a portion of the collected RO concentrate, also called RO reject herein, can be released to another system for further processing. For example, the RO reject can be delivered to another system, such as a solids treatment system, for a concentration process for discharge. The RO concentrate can comprise solids and/or salts filtered from the liquid stream of the urine and wastewater treatment system 100. In some examples, the RO reject can be received into a

concentrator (not shown) of a solids treatment system. For example, a concentrator can be configured to receive a liquid waste that can be heated. In an example, the RO reject from the urine and wastewater treatment system 300 can be received into the concentrator. Humidified air and/or an off gas can be released, and a concentrated output can be delivered to another system for further treatment or discharged from the system. The humidified air and/or off gas can be delivered to a main exhaust outlet and filtered before being released into the atmosphere. The gas filter in the main exhaust outlet can be configured such that the gas released is ISO 30500 compliant.

[00136] The buffer tank 302, the reservoir tank 308, the permeate tank 316, and the concentrate tank 318 can each have a vent outlet to release air or any gas in the respective tanks (not shown). Each of the vent outlets can be connected to a main gas exhaust line with a gas filter. For example, when the urine and wastewater treatment system 300 is a module in a single unit toilet system, the main exhaust line can also receive gas vented from other modules of the single unit toilet system. The gas filter can be configured so that the filtered gas release from the system is ISO 30500 compliant.

[00137] The urine and wastewater treatment system 300 can also comprise additional valves, sensors, switches, actuators, pumps, and the like to facilitate the operation of the urine and wastewater treatment system 300. For example, the buffer tank 302, the reservoir tank 308, the permeate tank 316, and/or the concentrate tank 318 can have sensors to detect the level of fluid in the respective tank. The urine and wastewater treatment system 300 can also comprise a controller 315. The controller 315 can be configured to interface with the valves, pumps, sensors, switches, and/or actuators in the system. For example, the controller 315 can be configured to operate the valves and/or pumps in response to a sensor indication from a tank, where the tank may have one or more sensors to indicate the level of the fluid within the tank. The controller 315 can be configured to control only the operation of the components of the urine and wastewater treatment system 300. In some examples, the controller can be integrated in a control system for a single unit toilet system in which the urine and wastewater treatment system 300 resides as a module.

[00138] FIG. 15 shows an example method for collection and separation of human waste as described herein. At box 1302, the method can include receiving a liquid waste from a tank. For example, the liquid waste can be received from a buffer tank. In some examples, the liquid waste can be urine and/or wastewater. For example, the liquid waste can be a clarified green stream, as described herein, comprising urine, water, and/or some trace toilet paper after at least a portion of

solids have been removed. In some examples, the buffer tank that is external to the urine and wastewater treatment system 300.

[00139] At box 1304, the method can include blowing air into the liquid waste stream to reduce the density of the liquid waste and to generate crossflow. For example, as discussed with respect to FIG. 1, the air pump or air blower can be positioned to introduce air to the fluid flow of the liquid stream at the feed to the UF membrane. For example, the air blower can diffuse air into the liquid stream using an air stone causing a bubbling effect. In another example, the air can be introduced by another distribution method.

[00140] At box 1306, the method can include filtering the liquid waste stream in an ultra-filtration stage to separate a first permeate and a first concentrate. The fluid can be filtered using an ultra-filtration membrane to separate a first permeate and a first concentrate. The fluid from the buffer tank and air mixing reduces the density of the fluid and displaces it upwards generating cross flow through the filter forming the first permeate.

[00141] At box 1308, the method can include discharging the first concentrate. The first concentrate from the UF membrane filter can contain some solids. The first concentrate can be discharged and/or returned to a pre-processing system for separation of solid waste in concentrate. For example, the concentrate can be returned to the same system that pre-processed green stream to clarify the green stream, then clarified and recirculated in the urine and wastewater treatment system. The first permeate, most of solids removed, can be directed to a next stage of filtering. For example, the first permeate can be pumped to a reservoir tank.

[00142] At box 1310, the method can include filtering the first permeate in a reverse osmosis stage to separate a second permeate and a second concentrate. The reverse osmosis stage can operate at a high pressure. For example, the first permeate can be delivered to a reverse osmosis membrane filter via a high-pressure pump. The first permeate can be filtered in the reverse osmosis membrane filter to separate a second permeate and a second concentrate. At box 1312, the method can include discharging the second permeate. In some examples, the second permeate can be reused. In some examples, the second permeate can be ISO 30500 compliant. Techniques for measuring chemical oxygen demand (COD), total nitrogen (total N), total phosphorus (total P), pH, total suspended solids (TSS), and *E. coli* (colony forming units or CFUs) are provided in the Examples.

[00143] As can be understood, the example method can be carried out in the order recited or in any other order that is logically possible. The method can omit steps or include additional steps. For example, the method can include a cleaning cycle. The cleaning cycle can include a backflow or pumping of a cleaning fluid through the system. In some examples, the method can be implemented automatically by the controller 315 based on sensor values, state of operation, user input, or other factors.

[00144] For example, the controller 315 can interface with sensors, valves, pumps, and motors of urine and wastewater treatment system 300. The controller 315 can comprise at least a processor and memory. The controller can be configured to implement a sequence of instructions to operate the sensors, valves, pumps, and motors based on the state of operation of the UF membrane filter 304 and/or the RO membrane filter 312. For example, the controller 315 can detect a level of fluid in each of the buffer tank 302, reservoir tank 308, permeate tank 316, and concentrate tank 318 via sensors in each of the respective tanks. For example, the controller 315 can actuate valves to empty said tanks and/or operate pumps to deliver fluids from said tanks. For example, the controller 315 can implement instructions for an RO flush cycle by turning off the high-pressure pump 310, closing an RO inlet valve, and draining the reservoir tank 308. After a time to drain the reservoir tank 308 to the concentrate tank 318, open the RO flush valve, turn on the high-pressure pump 310 and run the flush cycle for a predetermined time. For example, the liquid waste can be filtered by using a sensor to detect that the buffer tank 302 is full, the reservoir tank 308 is not full, and the RO flush cycle is complete. The controller 315 can implement instructions to start the UF sequence by turning on the air blower 314 and turning on the permeate pump 306 to filter the liquid waste pumped from the buffer tank 302. After a time has elapsed, the permeate pump 306 and air blower 314 can be turned off, then the concentrate can be drained from the UF membrane filter 304.

[00145] MICRO SUPER CRITICAL WATER OXIDATION SOLIDS TREATMENT SYSTEM

[00146] FIGS. 16-21 illustrate the mSCWO solids treatment system 400 of the water oxidation non-sewered single unit toilet system 10. The mSCWO solids treatment system 400 can be used to process a feces stream or brown stream of human waste, as described herein. By separating the brown stream prior to input, the mSCWO solids treatment system 400 can operate to process the solids contained therein. Moreover, a brown stream slurry or feces slurry can be obtained by

removing excess fluid from the brown stream and homogenizing the contents. For example, a feces slurry can be obtained from the buffer tank separation and homogenization system 200 connected to the mSCWO solids treatment system 400.

[00147] The method and system for solids treatment using water oxidation can include a batchwise process that heats and pressurizes a slurry of human waste to or above the critical point of water into the super critical fluid phase, killing all pathogens and reducing the complex organic molecules to simple chemical building blocks. The slurry of human waste, also referred to as a feces slurry or brown stream slurry herein, can comprise bodily wastes of a human, including urine and feces, as well as sanitation incidentals. The mSCWO solids treatment system 400 can be configured to receive a feces slurry from at least one separation or treatment system that processes bodily wastes of a human comprising urine and feces. For example, at least one separation or treatment system can partially separate liquid from a mixed content waste, reducing the amount of liquid in a feces stream or brown stream delivered to the mSCWO solids treatment system 400. For example, at least one separation or treatment system can comprise a homogenizer configured to form the feces slurry. The feces slurry can have a composition that is mostly solids with a liquid component. The liquid component can include urine, flush water, rinse water, wash water, fresh water, consumable water, potable water, and the like. In some examples, a portion of the liquid component of the bodily wastes can be processed separately prior to or in conjunction with the at least one homogenizer system that forms the feces slurry.

[00148] The feces slurry can be received as a slurry batch in an injector of the mSCWO solids treatment system 400, where it can be pressurized using compressed air. For example, the pressurized slurry batch can be injected into a mSCWO reactor. After receiving the slurry batch, the mSCWO reactor can be heated to or above the critical point of water into the super critical fluid phase over a heating time. The critical point of water is 374°C and 221 bar. For example, the mSCWO reactor can be heated to or above the critical point of water into the super critical fluid phase over approximately 2-3 minutes. The mSCWO reactor can maintain this state for holding time for treatment to inactivate pathogens. For example, the holding time can be maintained at this state for about 8 - 10 minutes. After the holding time has expired, an mSCWO effluent can be ejected, where the mSCWO effluent is a pathogen reduced or pathogen free output. The mSCWO effluent can comprise a mixture of solid ash and liquid waste. Once the reactor cycle is complete and the slurry has been processed, the pathogen free reactor output can be ejected

into a phase separator of a concentrator module. The concentrator module can comprise a combined concentrator and phase separator configured to separate solid ash from the liquid waste and gaseous products. The combined concentrator and phase separator can recover energy from the mSCWO effluent. The solid waste of the separated effluent can be transported to the drying belt in a drying tunnel, where it is dried and then transported to a disposal bin for removal from the system, and the liquid waste can be transported for further treatment or processing in a liquid waste treatment system, such as a urine and wastewater treatment system.

[00149] As shown in FIG. 16, the mSCWO solids treatment system 400 can include a reactor module 410, a gas handling module 440, and a concentrator module 450. The mSCWO solids treatment system 400 can be configured to receive and process a solids slurry comprising at least feces, also referred to as a feces slurry herein. The feces slurry can be received from a tank, for example a separation system configured to interface with the mSCWO solids treatment system 400. For example, the mSCWO solids treatment system 400 can receive a feces slurry from a buffer tank separation and homogenization system of a single unit toilet system. In some examples, the feces slurry can be mixed, macerated, or ground prior to delivery to the mSCWO solids treatment system 400. In some examples, the feces slurry can be optionally received into a homogenizer 418 of the reactor module 410, wherein the solids of feces slurry are broken down further. The brown stream slurry or feces slurry comprises feces and at least one of: urine, toilet paper, and water. Where the water can be wash water, flush water, fresh water, consumable water, potable water, and the like. For example, the total dry solid mass fraction of the brown stream slurry can range from about 7-12%. For example, in a day, the brown stream collected can have a mass of 3.967 kg with the total dry solids being 0.374 kg, resulting in a 9.4% solid mass fraction.

[00150] The reactor module 410 can include an injector 412 and an mSCWO reactor 414. In some examples, the reactor module 410 can also include a homogenizer 418. In some examples, a feces slurry can be received directly into the injector 412 from another system. In another example, as shown in FIG. 16, the feces slurry can also be received into reactor module 410 via the homogenizer 418. The optional homogenizer 418 can comprise a grinder or a macerator to further breakdown larger solids within the slurry received prior to delivery to the injector. The homogenizer 418 can be in fluid connection with the injector 412.

[00151] The injector 412 can be configured to receive a batch or dosing volume of the feces slurry. A volume of compressed air can be received from the gas handling module 440 to move

the volume of feces slurry from the injector 412 to the mSCWO reactor 414. The gas handling module 440 can include an injection pressure vessel 442 and a compressor 444. The injection pressure vessel 442 can have a constant volume, where the pressure and temperature can vary. In some examples, the gas handling module 440 can include sensors to measure the temperature, pressure, and heat of the injection pressure vessel 442. In some examples, the gas handling module 440 can optionally include an oxygen concentrator. The injector 412 can be configured to deliver a batch or dosing volume of feces slurry to the mSCWO reactor 414. For example, the gas handling module 440 can provide about 7 to 8 liters of air at 200 bar for a 22 ml feed. The injector 412 can be configured to provide the reactor with an amount of oxygen for a subsequent wet oxidation, where the oxygen can be delivered as compressed air.

[00152] The mSCWO reactor 414 can be configured to contain a volume of feces slurry to be treated. After receiving the slurry batch, the mSCWO reactor 414 can be heated to a temperature at or above the critical point of water over a heating time. The temperature can be above a wet oxidation ignition temperature. For example, the mSCWO reactor 414 can be heated to or above the critical point of water into the super critical fluid phase of water over approximately 2 minutes. The mSCWO reactor 414 can maintain the temperature at or above the critical point of water into the super critical fluid phase for a holding time to remove pathogens. For example, the holding time can be maintained at this state for about 8 to about 10 minutes. After the holding time has expired, an effluent or the pathogen free output can be ejected. The pathogen free reactor output or mSCWO effluent can comprise a mixture of solid ash and liquid waste. The mSCWO solids treatment system 400 can also include various sensors, valves, pumps, and control devices not shown in FIG. 16. The mSCWO solids treatment system 400 can comprise a controller 415 configured to control the operation of various sensors, valves, pumps, and control devices.

[00153] The concentrator module 450, also called a combined concentrator and separator herein, can comprise a separator 452 and a concentrator 454. The concentrator module 450 can include a separator 452, also called a phase separator 452 herein, configured to receive an mSCWO effluent from the mSCWO reactor 414. In some aspects, the separator 452 can be a phase separator and can also comprise a heat exchange portion, such as a heating surface. Once the reactor cycle is complete and feces slurry has been processed, the mSCWO effluent can be ejected into phase separator 452 of the concentrator module 450. The mSCWO effluent being the treated output of the mSCWO reactor 414. The phase separator 452 can be configured to separate solid ash from

the liquid and gaseous effluent. The separator 452 of the concentrator module 450 can be configured to extend into the interior volume of a concentrator 454, or surround a portion of the concentrator vessel 456, forming a combined unit. In some examples, the concentrator 454 of the concentrator module 450 can receive a liquid input from another system. For example, when the mSCWO solids treatment system is connected within a single unit toilet system, the liquid input can be received from a liquid treatment system, such as a urine and wastewater treatment system, connected to the mSCWO solids treatment system. The phase separator 452 can act as a heat exchanger configured to operate in conjunction with the concentrator 454 to utilize the heat from the mSCWO effluent to heat and condense the liquid waste contained within the concentrator 454. The concentrator module 450 is described in further detail herein. During operation, the phase separator 452 and the concentrator 454 can produce off gases. For example, the phase separator 452 can release carbon dioxide (CO₂) and the concentrator 454 can produce water vapor. The off gases can be filtered and output to the environment. For example, the gaseous output can comprise CO₂, CO, H₂O, and NO₂, as well as other nitrogen or sulfur oxides and the like. In some examples, the gaseous output of concentrator module 450 is configured to filter the gaseous output meet or exceed the ISO 30500 standard.

[00154] The drying tunnel 470 can comprise a dryer belt 490 configured to receive a condensed mSCWO effluent from the phase separator 452 of the concentrator module 450. An ash sludge can be separated from the condensed mSCWO effluent on the dryer belt 490 and processed to a dried ash. In an example, the dried ash output from the mSCWO solids treatment system 400 can meet or exceed the ISO 30500 standard. In an example, fluid separated from the condensed mSCWO effluent can be output to another system for further processing. In an example, the drying tunnel 470 can be configured with an outlet to send excess fluid backflow from the drying process of the dryer belt 490 to a connected buffer tank system. The concentrator module 450 can also output a concentrate formed from the liquid or liquid waste received into the concentrator 454 of the concentrator module 450. For example, the concentrate output can be delivered to dryer belt 490 in the drying tunnel 470 and dried as solids waste in a similar manner as the ash sludge. In some examples, a second option can include returning the concentrate output to another system for further processing. For example, some concentrate from the concentrator 454 can be delivered to a buffer tank separation system.

[00155] An example portion of a mSCWO solids treatment system 400 is shown in greater detail in FIG. 17. As shown, this example illustrates a portion of a gas handling module 440 connected to a reactor module 410. Compressed air can be received into the injection pressure vessel 442 from the compressor 444 (not shown) via the compressed air inlet 420. The injection pressure vessel 442 can have a constant volume and allow release of pressure via a pressure relief valve 448, if needed. In this example, the injection pressure vessel 442 can have a volume (V_{IPV}) of 500 ml. The pressure within the injection pressure vessel 442 can be 450 bar. The gas handling module 440 can further comprise an injection valve 446 to regulate the compressed air input into the injector 412. Similarly, dosing valves 422, 424 allow the flow of a feces slurry into and out of the injector 412. For example, the feces slurry can be received from a connected separation and homogenization system or an optional homogenizer 418 (not shown) via an inlet 416. In this example, the injector 412 can have dosing volume (V_{feed}) of 10 ml. The dosing volume can be injected as a slurry batch into the mSCWO reactor 414. The inlet valve 426 and outlet valve 428 for the mSCWO reactor 414 can be actuated by valve actuators 427, 429, respectively. The mSCWO reactor 414 can be configured to include a temperature sensor 438 and a pressure sensor 439 to measure the temperature and pressure within the mSCWO reactor 414.

[00156] FIG. 18 illustrates an example of a cross sectional view of a mSCWO reactor 414. As shown, the reactor body 432 surrounds the reactor vessel 434. In this example, the mSCWO reactor 414 can have a volume (V_R) of about 150 ml with a diameter (d_R) of less than 34 mm. The reactor body 432 can comprise a heater or can be embedded with heating elements 433. The reactor vessel 434 can be configured to receive an injection of a slurry batch from the injector 412 (not shown) and an input of compressed air to be heated to a temperature over a heating time, where the temperature being at or above the critical point of water into the super critical fluid phase. For example, the reactor vessel can have a volume of about 95 to 450 ml. The input can be received into the reactor vessel 434 via inlet 436, and once the reactor cycle is complete and feces slurry has been processed, the mSCWO effluent can be ejected via outlet 437. The inlet valve 426 and outlet valve 428 for the reactor vessel 434 can be actuated by valve actuators 427, 429, respectively.

[00157] In this example, the mSCWO reactor 414 can be configured to obtain treatment parameters including a temperature (T_R) of about 400°C to about 450°C, a pressure (p_R) of less than 350 bar, and a treatment period of (τ_R) of 150 s. The mSCWO reactor 414 can be insulated

to contain the heat. The mSCWO reactor 414 can be configured to include a temperature sensor 438 and a pressure sensor 439 to measure the temperature and pressure within the reactor vessel 434 of the mSCWO reactor 414. The reactor module 410 can further comprise a safety burst disc 430 to release pressure from the reactor vessel 434. The reactor module 410 can also include a pressure balance line. The treated output of the mSCWO reactor 414 can be received into the separator 452 of the concentrator module 450. In this example, the separator 452 can have a heat can have a volume of about 4 l and the walls of the separator 452 can be a heating surface configured as a heat exchanger.

[00158] FIGS. 19A and 19B illustrate the concentrator module 450 of the mSCWO solids treatment system 400. The concentrator module 450 can include a concentrator 454 and a separator 452. The separator 452 can be configured to receive the treated slurry batch or mSCWO effluent from the mSCWO reactor 414. The concentrator module 450 can also be a pasteurization and evaporation module that can interface with a concentrate tank of a liquids treatment system. For example, the liquids treatment system can output rejected fluids that contain solids and cannot be treated in the liquids treatment system. The rejected fluids can be reduced in volume by heating the fluids in the concentrator 454. In an example, pressurized air can be introduced into the concentrator such that humidified air and/or an off gas is released, and a concentrate remains. For example, when mSCWO solids treatment system 400 is part of a non-sewered single unit toilet system, the concentrator 454 can receive rejected fluids containing salts and/or other particulate solids from a liquids treatment system. The fluids contained within the concentrator 454 can also be heated, at least in part, by the separator 452 of the concentrator module 450.

[00159] The concentrator module 450 can be configured to utilize heat from the treated output of the mSCWO reactor 414 to heat a heating surface of the separator 452, which can heat the fluid contained within the concentrator vessel 456 of the concentrator 454. In an example, the separator 452 can be configured to extend into the concentrator vessel 456 such that the fluid within the concentrator vessel 456 can be in contact with heating surface of the separator 452. In another example, as shown in FIG. 19B, the separator 452 can be positioned external to the concentrator vessel 456 such that at least a portion of the heating surface of the separator 452 is in contact with the concentrator vessel 456 to transfer heat to the fluid contained within the concentrator vessel 456. The heat from the mSCWO effluent or treated output can be transferred to the walls of the separator 452. The ash from the treated output and condensed effluent can be delivered from the

separator 452 to the dryer belt 490, where the ash sludge settles on the dryer belt 490 of the drying tunnel 470.

[00160] As shown in FIG. 19A, the concentrator module 450 can comprise an open concentrator vessel 456 configured to hold a volume of fluid and a plurality of discs 466 housed within the open concentrator vessel 456. As shown in the cross-sectional view in FIG. 19B, the plurality of discs 466 can be arranged about an axle 468 that can be rotated by a motor 469 such that at least a portion of the plurality of discs 466 can be wetted by the fluid as the axle 468 rotates. Although the separator 452 can be configured to transfer heat to heat the fluid within the concentrator vessel 456, the concentrator module 450 can also include a heater 472 comprising heating coils 474 for supplemental heat, if needed. As shown in FIG. 19B, the heater 472 can be positioned such that heating coils 474 extend into the open concentrator vessel 456 to heat the volume of fluid contained within the open concentrator vessel 456. In some examples, the concentrator module 450 can also include an enclosure 462 positioned over the open concentrator vessel 456. In some examples, the concentrator module 450 can further comprise an air intake 463 and an air outlet 465 to provide air flow over the plurality of discs 466, that are wet, to aid in evaporation of the fluids to be concentrated. For example, a blower or one or more fans (not shown) can direct air flow through the concentrator 454. As shown in FIG. 19A, the enclosure 462 can be positioned to draw air through the concentrator vessel 456 and over the plurality of discs 466. The air intake 463 can be at a gap between the open concentrator vessel 456 and the enclosure 462. In another example, a system blower (not shown) can provide airflow in a similar manner over the plurality of discs 466 to aid in evaporation of the fluids to be concentrated.

[00161] In some examples, the concentrator 454 can receive a can receive a volume of rejected fluids containing salts and/or other particulate solids from a liquids treatment module. The volume of fluid can be contained by the open concentrator vessel 456. The volume of fluid can be maintained at a level that does not flow over or interfere with the rotation of the axle 468. The volume of fluid can be heated by the separator 452 and/or the heating coils 474 of the heater 472 to aid in evaporation of the fluid. In an example, pressurized air can be introduced into the concentrator such that humidified air and/or an off gas is released, and a concentrate remains. As the plurality of discs are rotated through the heated volume of fluid, the air intake 463 can be configured to direct air into the concentrator 454 over the plurality of discs 466 such that the fluid evaporates leaving the solids of the fluid received. The arrows shown in FIG. 4A indicate a

direction of air flow for evaporation in one example. In another example, the air intake 463 and air outlet 465 can be reversed such that the air flow is provided in the opposite direction. For example, a blower can be configured to draw air through the concentrator 454 or to operate in a reverse direction to blow air into the concentrator 454 and out the gap between the open concentrator vessel 456 and an enclosure 462.

[00162] In one example, the concentrate from the concentrator vessel 456 can be delivered to the dryer belt 490 and/or added to the ash sludge received on the dryer belt 490, to remove remaining moisture content. In an example, the dryer belt 490 can receive a concentrate from the concentrator 454 in addition to the effluent or ash sludge from the separator 452. For example, the dryer belt 490 be positioned in a drying tunnel 470 configured to force air onto the concentrate and/or ash sludge. For example, the drying tunnel 470 can evaporate up to 4 L/day or more of concentrate and/or ash. In some examples, the drying tunnel 470 can further comprise a means to discharge gas. In another example, up to 50% of the volume contained within the open concentrator vessel 456 can be returned to a buffer tank system or other treatment module for further processing.

[00163] As shown in FIG. 20, the drying tunnel 470 can comprise dryer belt 490 housed in a contained air duct system 482 to force air over the ash sludge and/or concentrate (not shown) to provide evaporative drying of the ash during transport. The drying tunnel 470 having a proximal end 484 and a distal end 486, with the dryer belt 490 extending about rollers 488a, 488b positioned at each of the proximal and distal ends 484, 486. The ash sludge and/or concentrate can be received in the drying tunnel 470 at the proximal end 484 via tunnel inlet 494. The dryer belt 490 is configured to convey the ash sludge from where the ash sludge is delivered from the separator 452 the proximal end 484 to the distal end 486, where the ash is released into a solids disposal bin via tunnel outlet 496. In some examples, the dryer belt 490 is arranged with an incline from the proximal end 484 to the distal end 486. In some examples, the dryer belt 490 can comprise holes or perforations to allow air flow. For example, the dryer belt 490 can be made of a polymer mesh or a metal mesh. The mSCWO solids treatment system 400 can also include a solids disposal bin to receive the dried ash or dried concentrate.

[00164] FIG. 21 shows an example method for treatment of human waste as described herein. At box 1402, the method can include receiving a slurry batch of feces into an injector vessel. For example, the slurry batch can be received from a collection tank, a homogenizer, or a separate

system that preprocesses the feces slurry. In an example, the slurry batch can be received in an optional homogenizer of the reactor module before being delivered into the injector vessel.

[00165] At box 1404, the method can include pressurizing the slurry batch with air. At box 1406, the method can include injecting the slurry batch into a reactor and providing the reactor with a sufficient amount of oxygen for a subsequent wet oxidation. The oxygen provided can be a volume of compressed air.

[00166] At box 1408, the method can include heating the slurry batch, within the reactor, for a heating time to a temperature that is at or above the critical point of water into the super critical fluid phase. The critical point of water is 374°C. The temperature can be a predetermined temperature above the wet oxidation ignition temperature.

[00167] At box 1410, the method can include maintaining the slurry batch at a minimum temperature, within the reactor, for a predetermined treatment time to produce a treated output, wherein the minimum temperature is greater than the critical point of water. At box 1412, the method can include ejecting the treated output into a phase separator. The treated output being an effluent comprising a liquid and ash.

[00168] At box 1414, the method can include separating the treated output into a solid ash volume, a liquid waste, and a gaseous effluent. In some examples, the method can further include releasing the treated output. For example, at box 1416, the method can include discharging a phase separator off-gas from the combined concentrator and phase separator. For example, at box 1418, the method can include discharging the liquid waste from the combined concentrator and phase separator. For example, the liquid waste can be transported to another system, such as a buffer tank system. For example, at box 1420, the method can include transporting the solid ash volume to a disposal bin for removal. In some examples, the solid ash volume is ISO 30500 compliant for solid waste output. In some examples, one or more steps can be omitted and/or added. The method can be carried out in the order recited or in any other order that is logically possible.

[00169] The features of the embodiments described herein are representative and, in alternative embodiments, certain features and elements can be added or omitted. It is to be understood that, unless otherwise indicated, the present disclosure is not limited to particular materials, manufacturing processes, or the like, as such can vary. It is also to be understood that the terminology used herein is for purposes of describing particular embodiments only and is not

intended to be limiting. It is also possible in the present disclosure that steps can be executed in different sequence where this is logically possible.

[00170] ASPECTS

[00171] The following list of exemplary aspects supports and is supported by the disclosure provided herein.

[00172] Aspect 1. A non-sewered toilet system, comprising:

a frontend separation system comprising a solids separator, the frontend separation system configured to receive a combined waste and separate the combined waste into a separated solids portion and a separated liquid portion and the separated solids portion comprising mostly solids and some fluid and the separated liquid portion comprising mostly fluid with some solids, the combined waste comprising at least one of urine and feces;

a buffer tank separation system comprising: a liquids collection tank, a solids collection tank, and a belt separator, the belt separator positioned to receive an input stream comprising at least one of: the separated solids portion and the separated liquids portion from the frontend separation system, the belt separator configured further separate the input stream to deliver a solids portion of the input stream to the solids collection tank and to deliver the liquids portion of the input stream to the liquids collection tank;

a liquid waste treatment system configured to receive liquid waste collected in the liquids collection tank of the buffer tank separation system, comprising:

an ultra-filtration stage comprising an ultra-filtration filter configured to separate the liquid waste into a first permeate and a first concentrate, and

a reverse osmosis stage configured to receive a first permeate from the ultra-filtration stage and separate the first permeate into a second permeate and a second concentrate, the second permeate being a useable water; and

a solids waste treatment system configured to receive a feces slurry from the buffer tank separation system, the feces slurry comprising the solids waste collected in the solids collection tank, comprising:

an injector vessel;

a reactor configured to receive an injection of a slurry batch of the feces slurry from the injector vessel and an input of compressed air to be heated to a temperature over a heating time, the temperature being at or above the critical point of water into the super critical fluid phase; and

a combined concentrator and phase separator comprising:

a concentrator vessel configured to receive and contain a liquid to be concentrated; and

a separator configured to receive a treated output from the reactor and separate solid ash volume from liquid and gaseous effluent.

[00173] Aspect 2. The system of aspect 1, wherein the reactor of the solids waste treatment system is configured to maintain the slurry batch at a minimum temperature, within the reactor, for a predetermined treatment time to produce the treated output.

[00174] Aspect 3. The system of aspect 2, wherein the minimum temperature is greater than 374°C.

[00175] Aspect 4. The system of aspect 2 or 3, wherein the minimum temperature for treatment in the reactor ranges from about 350°C to about 450°C.

[00176] Aspect 5. The system of any one of aspects 2-4, wherein the predetermined treatment time is about 150 s.

[00177] Aspect 6. The system of any one of aspects 2-5, wherein the reactor is configured to maintain a pressure of about 220 bar within the reactor for the predetermined treatment time.

[00178] Aspect 7. The system of any one of aspects 1-6, further comprising an injection pressure vessel configured to deliver the input of compressed air to the reactor, the input of compressed air being a volume of compressed air with an amount of oxygen for a subsequent wet oxidation of the slurry batch.

[00179] Aspect 8. The system of any one of aspects 1-7, wherein the separator of the combined concentrator and phase separator is configured as a heat exchanger to utilize heat from the treated output to heat a heating surface of a heat exchange portion of the separator that extends into or around the concentrator vessel to heat the liquid contained therein.

[00180] Aspect 9. The system of any one of aspects 1-8, wherein the combined concentrator and phase separator comprises a blower and a plurality of discs, the plurality of discs arranged about an axle and housed within the concentrator vessel configured to be rotated through the

contained liquid to wet said discs, the blower positioned to direct air into the concentrator vessel toward the plurality of discs to evaporate liquid from the wet discs.

[00181] Aspect 10. The system of any one of aspects 1-9, further comprising a drying tunnel comprises a dryer belt housed in a contained air duct system configured to force air toward the dryer belt.

[00182] Aspect 11. The system of aspect 10, wherein the dryer belt is configured to receive and dry the solid ash volume.

[00183] Aspect 12. The non-sewered toilet system of any one of aspects 1-11, wherein the buffer tank separation system further comprises a homogenizer connected to a solids outlet of the solids collection tank, the homogenizer configured to receive the collected solids portion and form the feces slurry, the feces slurry being a uniform and homogenized slurry.

[00184] Aspect 13. The non-sewered toilet system of any one of aspects 1-12, wherein the ultra-filtration stage comprises an ultra-filtration membrane filter, a first retention tank, and a first pump.

[00185] Aspect 14. The non-sewered toilet system of aspect 13, wherein the ultra-filtration stage is configured to deliver the first concentrate to the buffer tank separation system, the first concentrate comprising fluid rejected by the ultra-filtration filter.

[00186] Aspect 15. The non-sewered toilet system of any one of aspects 1-14, wherein the reverse osmosis stage comprises a reverse osmosis filter, a second retention tank, and a second pump.

[00187] Aspect 16. The non-sewered toilet system of aspect 15, wherein the reverse osmosis stage is configured to deliver a second concentrate to the second retention tank.

[00188] Aspect 17. The non-sewered toilet system of any one of aspects 16, wherein the concentrator vessel of the combined concentrator and phase separator of the solids waste treatment system is configured to receive a concentrate from the liquid waste treatment system and reduce the concentrate by heating and evaporation, forming a condensed effluent, the concentrate comprising fluid rejected by the reverse osmosis filter.

[00189] Aspect 18. The non-sewered toilet system of aspect 17, wherein the condensed effluent is delivered to a drying tunnel of the solids waste treatment system or a portion of the condensed effluent is delivered to the buffer tank separation system or both.

[00190] Aspect 19. The non-sewered toilet system of any one of aspects 1-18, wherein at least a portion of the useable water produced by the liquid waste treatment system is used as flush water.

[00191] Aspect 20. The non-sewered toilet system of any one of aspects 1-19, wherein the solids separator comprises:

- a vacuum tank having a top portion, a base, and a cylindrical wall, the vacuum tank, comprising:

- an inlet chamber formed within the vacuum tank at the top portion, the inlet chamber comprising an inlet and a chamber outlet;

- a solids containment portion formed in the base of the vacuum tank and positioned centrally within the vacuum tank, the solids containment portion comprising a solids outlet, the solids containment portion configured to hold a separated solids portion of the combined waste;

- a liquid containment portion formed in the base of the vacuum tank and contained within the vacuum tank surrounding the solids containment portion, the liquid containment portion comprising a liquids outlet, the liquid containment portion configured to hold a separated liquid portion of the combined waste portion;

- a separating filter having a cylindrical tubular shape and extending from the chamber outlet to the solids containment portion, the separating filter forming a central separation volume within the vacuum tank; and

- wherein the inlet chamber is configured to receive the combined waste via an inlet such that the combined waste is guided in a spiral about an interior surface of the inlet chamber and directed to the central separation volume, the liquid portion of the combined waste being allowed to flow through the separating filter to an outer portion surrounding the central separation volume and collect in the liquid containment portion of the base, the solids portion of the combined waste being contained within the central separation volume and collected in the solids containment portion of the base.

[00192] Aspect 21. The non-sewered toilet system of aspect 20, wherein, in the solids separator, the separating filter comprises a plurality of profile wires, each of the profile wires having a specified cross-section, the plurality of profile wires are arranged at a regular interval to

form a plurality of grooves extending from slits between the profile wires at an inner circumference of the cylindrical tubular shape to wider openings at an outer circumference of the cylindrical tubular shape.

[00193] Aspect 22. The non-sewered toilet system of aspect 20 or 21, wherein, in the solids separator, the base of the vacuum tank has an inclined base within the liquid containment portion such that a flow of the liquid portion of the combined waste collected in the liquid containment portion of the base is directed to the liquids outlet.

[00194] Aspect 23. The non-sewered toilet system of any one of aspects 20-22, wherein, in the solids separator, the solids containment portion is funnel or conical shaped to direct the solids portion of the combined waste to the solids outlet.

[00195] Aspect 24. The non-sewered toilet system of any one of aspects 20-23, wherein, in the solids separator, the solids portion of the combined waste collected in the solids containment portion is released via the solids outlet after a pressure is applied to the vacuum tank.

[00196] Aspect 25. The non-sewered toilet system of any one of aspects 20-24, wherein, in the solids separator, the liquid portion of the combined waste collected in the liquid containment portion is released via the liquids outlet by gravity.

[00197] Aspect 26. The non-sewered toilet system of any one of aspects 20-25, wherein the solids separator further comprises a first actuator configured to operate a first valve at the solids outlet and a second actuator configured to operate a second valve the liquids outlet.

[00198] Aspect 27. The non-sewered toilet system of aspect 26, wherein, in the solids separator, the first valve is configured to open when an overpressure is applied to the vacuum tank, releasing the solids portion of the combined waste collected in the solids containment portion.

[00199] Aspect 28. The non-sewered toilet system of aspect 26 or 27, wherein, in the solids separator, the second valve is actuated after the first valve, releasing the liquid portion of the combined waste collected in the liquid containment portion.

[00200] Aspect 29. The non-sewered toilet system of any one of aspects 1-28, wherein the frontend system further comprises a vessel configured to receive at least urine and feces and a flush tank configured to deliver a volume of flush water to the vessel to form a combined waste within the vessel, wherein the vessel comprises a main valve.

[00201] Aspect 30. The non-sewered toilet system of aspect 29, wherein a vacuum is applied to vacuum tank of the solids separator by a vacuum pump to evacuate the combined waste within the vessel as the main valve is actuated.

[00202] Aspect 31. The non-sewered toilet system of aspect 29 or 30, further comprising a user interface configured for a user to select a flush mode comprising at least one of: a urine event mode and a defecation event mode.

[00203] Aspect 32. The non-sewered toilet system of any one of aspects 1-31, wherein the buffer tank separation system further comprises at least one inlet configured to receive an input stream.

[00204] Aspect 33. The non-sewered toilet system of aspect 32, wherein the belt separator of the buffer tank separation system comprises a perforated belt looped between two rollers, the belt separator positioned to receive the input stream via the at least one inlet onto the perforated belt of the belt separator.

[00205] Aspect 34. The non-sewered toilet system of aspect 33, wherein the perforated belt of the belt separator comprises pores configured to allow the liquids portion of the input stream to pass through to the liquids collection tank and to retain the solids portion on the perforated belt.

[00206] Aspect 35. The non-sewered toilet system of aspect 33 or 34, wherein the buffer tank separation system further comprises a squeegee configured to remove the solids portion of the input stream from the perforated belt of the belt separator.

[00207] Aspect 36. The non-sewered toilet system of any one of aspects 1-35, wherein the buffer tank separation system further comprises a liquid deflector positioned beneath the belt separator configured to direct at least some of the liquids portion of the input stream to the liquids collection tank.

[00208] Aspect 37. The non-sewered toilet system of any one of aspects 1-36, wherein the liquids collection tank of the buffer tank separation system further comprises a sludge outlet and a bottom wall configured to direct a sludge stream to the sludge outlet, the sludge stream comprising solids settled from the liquids portion contained in the liquids collection tank.

[00209] Aspect 38. The non-sewered toilet system of any one of aspects 1-37, wherein the solids collection tank of the buffer tank separation system further comprises an overflow outlet.

[00210] Aspect 39. The non-sewered toilet system of any one of aspects 32-38, wherein, in the buffer tank separation system, the at least one inlet comprises a solids inlet configured to receive

a mostly solids input stream comprising feces, the solids inlet comprising a chamber, an offset chamber inlet, and a chamber outlet, the chamber shaped such that the solids input stream received via the offset chamber inlet is directed toward an interior wall surface of the chamber to flow out the chamber outlet onto the belt separator.

[00211] Aspect 40. The non-sewered toilet system of any one of aspects 32-39, wherein, in the buffer tank separation system, the at least one inlet comprises a liquids inlet configured to receive and direct a mostly liquids input stream onto the belt separator.

[00212] Aspect 41. The non-sewered toilet system of any one of aspects 32-40, wherein, in the buffer tank separation system, the at least one inlet comprises one or more auxiliary input ports configured to receive at least one of: a urine stream comprising mostly urine, a sludge stream received from the liquids collection tank, an overflow stream received from the solids collection tank, a reject stream received from a liquids treatment system, a filtrate received from a feces treatment system, and a condensed effluent received from a feces treatment system.

[00213] Aspect 42. The non-sewered toilet system of any one of aspects 33-41, wherein the buffer tank separation system further comprises a motor configured to drive at least one of the two rollers of the belt separator.

[00214] Aspect 43. The non-sewered toilet system of any one of aspects 1-42, wherein the liquid waste treatment system further comprises a diffuser positioned at an inlet to the ultra-filtration filter, the diffuser connected to an air blower and configured to introduce air into the liquid waste to reduce the density of the liquid waste and to generate a crossflow within the ultra-filtration filter.

[00215] Aspect 44. The non-sewered toilet system of aspect 43, wherein, in the liquid waste treatment system, the diffuser comprises an air stone.

[00216] Aspect 45. The non-sewered toilet system of any one of aspects 1-44, wherein the ultra-filtration stage of the liquid waste treatment system comprises a first pump configured to deliver the first permeate to a first retention tank.

[00217] Aspect 46. The non-sewered toilet system of any one of aspects 1-45, the reverse osmosis stage of the liquid waste treatment system comprises a second pump configured to deliver the second permeate to a second retention tank.

[00218] Aspect 47. The non-sewered toilet system of aspect 46, wherein the second pump is configured to operate at a high pressure.

[00219] Aspect 48. The non-sewered toilet system of aspect 46 or 47, wherein the second pump is configured to operate at a pressure of about 30 to 35 bar.

[00220] Aspect 49. The non-sewered toilet system of any one of aspects 1-48, wherein the second permeate discharged as the useable water is a non-potable water for use or re-use from the liquid waste treatment system meets at least one of:

chemical oxygen demand (COD) ≤ 50 mg/L;

total suspended solids (TSS) ≤ 10 mg/L;

total Nitrogen (N) $> 70\%$ reduction relative to the total N in the liquid waste received into the UF stage;

total Phosphorus (P) $> 80\%$ reduction relative to the total P in the liquid waste received into the UF stage; and

E. coli ≤ 100 per L.

[00221] Aspect 50. The non-sewered toilet system of any one of aspects 1-49, wherein, in the liquid waste treatment system, the ultra-filtration stage operates at a first pressure and the reverse osmosis stages operate at a second pressure.

[00222] Aspect 51. The non-sewered toilet system of aspect 50, wherein, in the liquid waste treatment system, the reverse osmosis stage operates at a high pressure.

[00223] Aspect 52. The non-sewered toilet system of any one of aspects 1-51, wherein, in the liquid waste treatment system, a controller enables automated operation of the ultra-filtration stage and the reverse osmosis stage.

[00224] Aspect 53. The non-sewered toilet system of any one of aspects 1-52, wherein a controller enables automated operation of at least one of: the frontend separation system, the buffer tank separation system, the liquid waste treatment system, and the solids waste treatment system.

[00225] Aspect 54. The non-sewered toilet system of any one of aspects 1-53, wherein at least the solids separator, the buffer tank separation system, the liquid waste treatment system, and the solids waste treatment system are housed in a single unit.

[00226] Aspect 55. A method for treatment of human waste, the method comprising:

receiving, into a frontend separation system, a human waste comprising at least one of urine and feces;

separating the human waste into at least one of a mostly liquid stream and a mostly solids stream;

delivering the mostly liquid stream from the frontend separation system to a buffer tank separation system;

receiving the mostly liquid stream via a first inlet onto a belt separator and separating at least some of the solids from the mostly liquid stream;

depositing the solids separated from the mostly liquid stream into the solids collection tank and deposit the remaining portion of the mostly liquid stream into a liquids collection tank for short-term storage and passive separation of liquid from remaining solid waste received into the liquids collection tank;

delivering the mostly solids stream from the frontend separation system to the buffer tank separation system;

receiving the mostly solids stream via a second inlet onto the belt separator and separating most of the solids from the mostly solids stream;

depositing the solids separated from the mostly solids stream into the solids collection tank and deposit the remaining portion of the mostly solids stream into the liquids collection tank for short-term storage and passive separation of liquid from remaining solid waste received into the liquids collection tank;

separating pathogens from a liquid waste received from a volume of collected liquids separated within the liquids collection tank in a urine and wastewater treatment system;

delivering a volume of collected solids settled within the solids collection tank to a homogenizer to form a feces slurry;

inactivating pathogens in the feces slurry in a water oxidation solids treatment system.

[00227] Aspect 56. The method of aspect 55, wherein inactivating pathogens in the feces slurry comprises:

receiving a slurry batch of feces into an injector of the of the water oxidation solids treatment system;

pressurizing the slurry batch with air;

injecting the slurry batch into a reactor;

heating the slurry batch, within the reactor, to a temperature over a heating time, the temperature being over the temperature of the critical point of water into the super critical fluid phase;

maintaining the slurry batch at a minimum temperature, within the reactor, for a predetermined treatment time to produce a treated output, wherein the minimum temperature is greater than the critical point of water;

ejecting the treated output into a phase separator of the of the water oxidation solids treatment system;

separating the treated output into a solid ash volume, a liquid waste, and a gaseous effluent; and

transporting the solid ash volume to a disposal bin for removal.

[00228] Aspect 57. The method for treatment of human waste of aspect 56, wherein injecting the slurry batch into the reactor further comprises providing the reactor with an amount of oxygen for a subsequent wet oxidation.

[00229] Aspect 58. The method for treatment of human waste of aspect 56 or 57, wherein the temperature is a temperature above a wet oxidation ignition temperature.

[00230] Aspect 59. The method for treatment of human waste of any one of aspects 56-58, further comprising receiving a liquid to be concentrated into a concentrator of the water oxidation solids treatment system.

[00231] Aspect 60. The method for treatment of human waste of any one of aspects 56-59, wherein receiving a slurry batch of feces further comprises homogenizing the slurry batch prior to receiving the slurry batch into the injector.

[00232] Aspect 61. The method for treatment of human waste of any one of aspects 56-60, further comprising discharging off-gasses and liquid waste from the combined concentrator and phase separator of the water oxidation solids treatment system.

[00233] Aspect 62. The method for treatment of human waste of any one of aspects 56-61, wherein the minimum temperature for treatment in the reactor ranges from about 350°C to about 450°C.

[00234] Aspect 63. The method for treatment of human waste of any one of aspects 56-62, wherein the predetermined treatment time is about 150 s.

[00235] Aspect 64. The method for treatment of human waste of any one of aspects 56-63, wherein maintaining the slurry batch at the minimum temperature comprises maintaining a pressure within the reactor for the predetermined treatment time.

[00236] Aspect 65. The method for treatment of human waste of any one of aspects 56-64, wherein the critical point of water is 374°C.

[00237] Aspect 66. The method of any one of aspects 55-65, wherein the mostly liquid stream is less than 5% dry solids content by volume and the mostly solids stream is about 1% to about 25% dry solid contents by volume.

[00238] Aspect 67. The method of any one of aspects 55-66, further comprising:

receiving a liquid waste comprising the volume of collected liquids separated within the liquids collection tank to a urine and wastewater treatment system;

blowing air into the liquid waste to reduce the density of the liquid waste and to generate crossflow;

filtering the liquid waste in an ultra-filtration stage to separate a first permeate and a first concentrate;

discharging the first concentrate to the buffer tank separation system;

filtering the first permeate in a reverse osmosis stage to separate a second permeate and a second concentrate;

recirculating the second concentrate to filter in the reverse osmosis stage; and

discharging the second permeate as useable water.

[00239] Aspect 68. The method of aspect 67, wherein the second permeate discharged as useable water meets at least one of:

chemical oxygen demand (COD) ≤ 50 ;

total suspended solids (TSS) ≤ 10 mg/L;

total Nitrogen (N) $> 70\%$ reduction relative to the total N of the liquid waste received into the ultra-filtration stage;

total Phosphorus (P) $> 80\%$ reduction relative to the total P of the liquid waste received into the ultra-filtration stage; and

E. coli $\leq$ 100 per L.

Aspect 69. The method of aspect 67 or 68, further comprising:

delivering a volume of the second concentrate to a concentrator; and

heating the volume of the second concentrate forming a condensed effluent by evaporation.

[00240] Aspect 70. The method of any one of aspects 67-69, wherein the reverse osmosis stages operates at a high pressure.

[00241] Aspect 71. The method of any one of aspects 55-70, wherein separating the human waste into at least one of a mostly liquid stream and a mostly solids stream comprises:

receiving a human waste into a vessel having a main outlet, the human waste comprising at least one of: urine and feces;

receiving a volume of flush water forming a combined waste within the vessel;

evacuating the combined waste through the main outlet of the vessel into the solids separator; and

separating the combined waste into a liquid portion comprising mostly fluid with some solids and a solids portion comprising mostly solids and some fluid.

[00242] Aspect 72. The method of aspect 71, wherein evacuating the combined waste comprises: using a vacuum pump to form a weak vacuum to transport the combined waste to the solids separator.

[00243] Aspect 73. The method of aspect 72 or 72, wherein the combined waste is received into the inlet chamber of the solids separator via the inlet, the inlet being positioned to receive the combined waste tangentially and direct the combined waste along a circumferential interior wall of the inlet chamber to decelerate the combined waste.

[00244] Aspect 74. The method of any one of aspects 71-73, wherein the solids portion of the combined waste collected in the solids containment portion is released via the solids outlet after a pressure is applied to the vacuum tank.

[00245] Aspect 75. The method of any one of aspects 71-73, wherein the liquid portion separated from the combined waste comprises less than 5% dry solids content, the dry solids content comprising at least one of feces and toilet paper.

[00246] Aspect 76. The method of any one of aspects 71-73, wherein the solids portion separated from the combined waste comprises about 1%-25% dry solids content, the solids content comprising at least one of feces and toilet paper.

[00247] Aspect 77. The method of any one of aspects 71-73, wherein the volume of flush water comprises a predetermined amount of flush water based on whether the human waste received is due to a urination event or a defecation event.

[00248] Aspect 78. The method of any one of aspects 55-77, wherein, in the buffer tank separation system, the method comprises:

receiving, onto a belt separator, an input stream comprising at least one of: solids and liquids;

separating, by the belt separator, the input stream into a solids portion and a liquids portion;

delivering the liquids portion to a liquids collection tank for sedimentation;

delivering the solids portion to a solids collection tank.

[00249] Aspect 79. The method of aspect 78, wherein the input stream comprises at least one of: a mostly liquids input stream, a mostly solids input stream comprising feces, a urine stream comprising mostly urine, a sludge stream received from the liquids collection tank, an overflow stream received from the solids collection tank, a reject stream received from a liquids treatment system, a filtrate received from a feces treatment system, and a condensed effluent received from a feces treatment system.

[00250] Aspect 80. The method of aspect 79, wherein, when the input stream is a mostly solids input stream comprising feces, the input stream is received via a solids inlet comprising a chamber, an offset chamber inlet, and a chamber outlet, the chamber shaped such that the solids input stream received via the offset chamber inlet is directed toward an interior wall surface of the chamber to flow out the chamber outlet onto the belt separator.

[00251] Aspect 81. The method of any one of aspects 78-80, wherein the belt separator comprises a perforated belt looped between two rollers, the belt separator positioned to receive an input stream comprising at least one of: solids and liquids, the input stream received via the at least one inlet onto the belt of the belt separator, the belt separator configured to deliver the solids

portion of the input stream to the solids collection tank and to deliver the liquids portion of the input stream to the liquids collection tank.

[00252] Aspect 82. The method of any one of aspects 78-81, wherein the perforated belt of the belt separator comprises pores configured to allow the liquids portion of the input stream to pass through to the liquids collection tank and to retain the solids portion on the perforated belt.

[00253] Aspect 83. The method of any one of aspects 78-82, wherein delivering the solids portion to the solids collection tank comprises removing the solids portion of the input stream from the perforated belt of the belt separator with a squeegee.

[00254] Aspect 84. The method of any one of aspects 78-83, wherein delivering the liquids portion to a liquids collection tank for sedimentation comprises directing at least some of the liquids portion of the input stream to the liquids collection tank via a liquid deflector positioned beneath the belt separator.

[00255] Aspect 85. The method of any one of aspects 78-84, further comprising releasing a collected liquids portion from the liquids collection tank to a liquids treatment system.

[00256] Aspect 86. The method of any one of aspects 78-85, further comprising delivering a sludge portion from the liquids collection tank to the belt separator via a sludge outlet.

[00257] Aspect 87. The method of any one of aspects 78-86, further comprising delivering an overflow portion from the solids collection tank to the belt separator via an overflow outlet.

[00258] Aspect 88. The method of any one of aspects 78-87, further comprising forming, in a homogenizer, a uniform and homogenized slurry from a collected solids portion output from the solids collection tank.

[00259] Aspect 89. The method of aspect 88, further comprising releasing the slurry to a feces treatment system.

[00260] Aspect 90. The method of any one of aspects 67-89, further comprising pumping the first permeate to a reservoir tank.

[00261] Aspect 91. The method of aspect 90, further comprising pumping the first permeate from the reservoir tank through the reverse osmosis stage at a high pressure.

[00262] Aspect 92. The method of any one of aspects 67-91, further comprising recirculating the second concentrate to filter in the reverse osmosis stage.

[00263] Aspect 93. The method of any one of aspects 67-92, wherein the liquid waste comprises at least one of urine, feces, rinse water, and trace toilet incidentals.

[00264] Aspect 94. The method of any one of aspects 67-93, wherein the liquid waste is a clarified liquid received from a buffer tank system.

[00265] Aspect 95. The method of any one of aspects 67-94, wherein discharging the first concentrate comprises discharging the first concentrate to a system for separation of solid waste in concentrate.

[00266] Aspect 96. The method of any one of aspects 67-95, wherein filtering the first permeate in the reverse osmosis stage comprises receiving the first permeate in a reservoir tank and recirculating the second concentrate.

[00268] The features of the embodiments described herein are representative and, in alternative embodiments, certain features and elements can be added or omitted. It is to be understood that, unless otherwise indicated, the present disclosure is not limited to particular materials, manufacturing processes, or the like, as such can vary. It is also to be understood that the terminology used herein is for purposes of describing particular embodiments only and is not intended to be limiting. It is also possible in the present disclosure that example methods can omit steps or include additional steps or can be executed in different sequence where this is logically possible.

[00269] EXAMPLES

[00270] The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how the compounds, compositions, articles, devices and/or methods claimed herein are made and evaluated, and are intended to be purely exemplary of the disclosure and are not intended to limit the scope of what the inventors regard as their disclosure. Efforts have been made to ensure accuracy with respect to numbers (e.g., amounts, temperature, etc.), but some errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, temperature is in °C or is at ambient temperature, and pressure is at or near atmospheric.

[00271] Samples of the liquid output of the urine and wastewater treatment system were tested to measure chemical oxygen demand (COD), total nitrogen (total N), total phosphorus (total P), pH, total suspended solids (TSS), and *E. coli* (colony forming units or CFUs). Examples of tested liquid output parameters compared to the ISO 30500 standard are shown in TABLE 1. Exemplary methods for testing the liquid output parameters are provided in the Test Protocols below.

[00272] TABLE 1.

parameter	ISO 30500 liquid effluent performance threshold	Exemplary UWW System 1			Exemplary UWW System 2		
		range	average	number of samples	range	average	number of samples
COD	Category A ¹ ≤ 50 mg/L Category B ² ≤ 150 mg/L	20 – 404 mg/L	87 mg/L	18	24 – 38 mg/L	33 mg/L	3
Total N	>70 % reduction	71.8 – 98.7 % reduction	86.7 % reduction	17	77.8 – 97.9 % reduction ³	86.5 % reduction	7
Total P	>80 % reduction	99.7 – 100 % reduction	99.9 % reduction	17	99.8 – 100 % reduction	99.9 % reduction	7
pH	6.0 – 9.0	9.05 – 10.14	9.70	18	8.94 – 9.92	9.46	6
TSS	Category A ≤ 10 mg/L Category B ≤ 30 mg/L	below detection – 34 mg/L	-	18	below detection – 1 mg/L	-	4
E. coli	≤ 100 per L	below detection	-	11	below detection	-	5
¹ Per ISO 30500: “Category A usage refers to unrestricted urban uses that comprise all uses where public access is not restricted (e.g. landscape irrigation, toilet flushing).” ² Per ISO 30500: “Category B usage refers to discharge into surface water and other restricted urban uses that comprise all uses where public access is controlled or restricted by physical or institutional barrier (e.g. fences, temporal access restriction).” ³ % reductions are measured relative to the concentrations of liquid influent to the Urine and Wastewater Treatment System (i.e., immediately prior to the ultrafiltration stage).							

[00273] TEST PROTOCOLS

[00274] **Chemical Oxygen Demand Test Protocol**: The chemical oxygen demand (COD) is measured for samples taken using the Urine and Wastewater Treatment System Sampling Procedure as described herein. Chemical oxygen demand can be measured by any method known in the art such as, for example, using a USEPA Reactor Digestion Method kit manufactured by HACH® Company (Loveland, CO, USA). Spectrophotometers and colorimeters DR 6000, DR 5000, DR 3900, DR 3800, DR 2800, DR 2700, DR 1900, and DR 900 from HACH® Company are suitable for performing this test although COD can also be performed on UV-Vis spectrophotometers and/or colorimeters from other manufacturers. For the listed instruments, the test is performed as follows:

[00275] Samples can be collected in clean glass bottles and/or plastic containers free of organic contamination. Samples are tested as quickly as possible after collection.

[00276] For analyzing a typical sample, a reactor is initialized and preheated to 150 °C. A DRB 200 reactor from HACH® Company is used herein; however, any suitable reactor can be

used by following manufacturer-provided protocols. Different sample vials containing pre-packaged reagents are obtained from HACH® Company based on the expected COD, with wider and narrower detection limits available. The ordinarily-skilled artisan will be able to choose the appropriate vials and reagents based on expected COD of the sample to be measured as well as previous test results.

[00277] 2 mL of sample is added to a typical vial containing digestion reagents, or for detection in the 250-15,000 mg/L range, 0.20 mL of sample is added to the vial using a micropipette. A second vial is prepared as a blank using deionized water. Both the sample and the blank are externally rinsed and wiped with a paper towel or lint-free wipe to dry. Vials are inverted to mix and placed in the reactor, where they are heated for 2 hours. The reactor is turned off and the vials are allowed to cool for 20 minutes or until the temperature reaches 120°C. Vials are inverted several times and placed in a rack to cool.

[00278] The blank vial is externally cleaned and placed into the colorimeter or spectrophotometer. A zero reading is taken. The prepared sample vial is externally cleaned and placed into the colorimeter or spectrophotometer and a COD reading is taken. The blank can be used for several sample vials in the same lot of reagent vials and only requires replacement if absorbance changes by at least 0.01 absorbance units over time.

[00279] If desired, instrumental accuracy is verified using a series of standard solutions of known concentration. Factory calibration of the instrument can be adjusted to reflect known values of the standard solutions.

[00280] Total Nitrogen Test Protocol: The total nitrogen (total N) is measured for samples taken using the Urine and Wastewater Treatment System Sampling Procedure as described herein. Total nitrogen can be measured by any method known in the art such as, for example, using a Persulfate Digestion Method kit manufactured by HACH® Company (Loveland, CO, USA). Spectrophotometers and colorimeters DR 6000, DR 5000, DR 3900, DR 3800, DR 2800, DR 2700, DR 1900, and DR 900 from HACH® Company are suitable for performing this test although total nitrogen detection can also be performed on UV-Vis spectrophotometers and/or colorimeters from other manufacturers. For the listed instruments, the test is performed as follows:

[00281] Samples are tested as quickly as possible after collection. For analyzing a typical sample, a reactor is initialized and preheated to 105 °C. A DRB 200 reactor from HACH® Company is used herein; however, any suitable reactor can be used by following manufacturer-

provided protocols. Nitrogen Hydroxide Digestion Reagent vials from HACH® Company are used herein; these contain pre-measured reagents useful for testing total nitrogen. The contents of one pre-measured packet of nitrogen persulfate are added to a first reagent vial for use in measuring a sample, and to a second reagent vial for use in measuring a blank. 0.5 mL of sample is added to one vial and 0.5 mL of deionized water is used to the second vial. Deionized water must be free of all nitrogen-containing species. The vials are capped and shaken vigorously for 30 seconds. The shaken vials are placed in the reactor for 30 minutes. Following reaction, the vials are removed from the reactor and allowed to cool to room temperature.

[00282] Pre-measured packets of Total Nitrogen Reagent A provided by HACH® Company are added to the sample and blank vials. The vials are capped and shaken for 30 seconds, then reacted for 3 minutes. After 3 minutes, the caps are removed from the vials and pre-measured packets of Total Nitrogen Reagent B provided by HACH® Company are added to the vials. The vials are capped and shaken for 15 seconds, then reacted for 2 minutes. Following reaction, 2 mL of the digested samples from the vials are added to separate Total Nitrogen Reagent C vials provided by HACH® company. A similar procedure is followed for deionized water blanks. The reagent vials are capped and inverted slowly 10 times to mix. After 5 minutes, the vials are cleaned externally and measured using a spectrophotometer or colorimeter.

[00283] Blanks can be saved for up to 7 days if kept in the dark at room temperature. When suspended solids appear in the blanks, they should be discarded and new blanks prepared. This procedure is effective at detecting at least 95% of nitrogen in ammonium chloride, ammonium sulfate, ammonium acetate, glycine, urea, and other organic nitrogen species.

[00284] If desired, instrumental accuracy is verified using standard additions to spike a fresh sample, or using a series of standard solutions of known concentration. Instrumental accuracy across different sources of nitrogen can be verified by preparing stock solutions using known amounts of different nitrogen species (e.g. ammonia, glycine, nicotinic acid-p-toluenesulfonic acid, or the like).

[00285] **Total Phosphorus Test Protocol:** The total phosphorus (total P) is measured for samples taken using the Urine and Wastewater Treatment System Sampling Procedure as described herein. Total phosphorus can be measured by any method known in the art such as, for example, using a USEPA PhosVer® 3 with Acid Persulfate Digestion Method kit manufactured by HACH® Company (Loveland, CO, USA). Spectrophotometers and colorimeters DR 6000, DR

5000, DR 3900, DR 3800, DR 2800, DR 2700, DR 1900, and DR 900 from HACH® Company are suitable for performing this test although total phosphorus detection can also be performed on UV-Vis spectrophotometers and/or colorimeters from other manufacturers. For the listed instruments, the test is performed as follows:

[00286] Samples are tested as quickly as possible after collection. When samples are processed, pH should be adjusted to 7 using 5.0 N sodium hydroxide. Volume additions at any stage in the process (e.g. acidification, pH adjustment) should be corrected for when interpreting test results.

[00287] For analyzing a typical sample, a reactor is initialized and preheated to 150 °C. A DRB 200 reactor from HACH® Company is used herein; however, any suitable reactor can be used by following manufacturer-provided protocols. 5.0 mL of sample to be tested is added to a vial, followed by a pre-measured amount of potassium persulfate provided as part of a test kit available from HACH® Company. The sample is shaken to dissolve any powder and the sample vial is inserted into the reactor and allowed to react for 30 minutes. This reaction converts organic and condensed inorganic phosphates to reactive orthophosphate. The sample vial is removed from the reactor and allowed to cool to room temperature. 2 mL of 1.54 N sodium hydroxide is added to the sample vial and the vial is capped and inverted to mix. The vial is wiped with a lint-free cloth or wipe to clean and dry the outer surface of the vial, and the vial is then inserted into a cell holder in the spectrophotometer or colorimeter. The spectrophotometer or colorimeter is zeroed and a pre-measured amount of molybdate and ascorbic acid (herein, from a PhosVer® 3 powder pillow available from HACH® company) is added to the vial. The vial is shaken for 20-30 seconds to disperse the powder, which does not dissolve completely. After a 2-minute reaction time, orthophosphate in the sample has reacted with molybdate to produce a mixed complex having an intense blue color. The vial is again wiped with a lint-free cloth or wipe and inserted into the spectrophotometer or colorimeter and a total phosphorus reading is taken using absorbance at 880 nm for spectrophotometers or 610 nm for colorimeters (for a reduced phosphate/molybdate complex).

[00288] In a typical test, range for total phosphorus is from 0.06 to 3.5 mg/L PO_4^{3-} . Samples showing a higher concentration should be diluted and re-tested for accuracy of reporting. If desired, instrumental accuracy is verified using standard additions to spike a fresh sample, or using a series of standard solutions of known concentration.

[00289] Total Suspended Solids Test Protocol: The total suspended solids (TSS) are measured for samples taken using the Urine and Wastewater Treatment System Sampling Procedure as described herein. Total suspended solids can be measured using any technique known in the art such as, for example, the test for Residue, Non-Filterable (Gravimetric, Dried at 103-105 °C) protocol from the US EPA National Exposure Research Laboratory. This method is useful for determining from about 4 mg/L to about 20,000 mg/L of suspended solids.

[00290] Briefly, a glass fiber filter is placed into a membrane filter apparatus. A vacuum is applied and the filter is washed with at least three 20 mL volumes of distilled water. Vacuum is applied until all traces of water are removed. The filter is dried in an oven at 103-105 °C for one hour and stored in a desiccator until needed. The filter is weighed immediately before use and handled with forceps or tongs only.

[00291] Sample volume is selected such that at least 1.0 mg of residue remains on the filter for a 4.7 cm filter. For other filter diameters, the ordinarily-skilled artisan will be able to select a sample volume equal to about 7 mL/cm² of filter area and collect a weight of residue proportional to 1.0 mg.

[00292] The filter is weighed and placed in the filtering apparatus. Suction is applied. The filter is wetted with a small volume of distilled water. The sample is shaken vigorously and the preselected sample volume is applied to the filter using an appropriate means for the volume selected (e.g. graduated cylinder). Suction continues until all traces of water are removed. The graduated cylinder or other apparatus is washed with distilled water three times and the washes are applied to the filter. The filter, non-filterable residue, and filter apparatus are further washed with distilled water three times and all traces of water are again removed. The filter is removed from the filter apparatus and dried for at least one hour at 103-105 °C. The filter is allowed to cool in a desiccator and is weighed. The drying cycle is repeated until a constant weight is obtained.

[00293] pH Test Protocol: The pH is measured for samples taken using ___ as described herein. A probe from a calibrated digital pH meter or water quality meter with pH measurement capability is immersed in the sample and pH value is displayed on a screen on the meter. Various pH meters and/or water quality meters can be used including the Myron L Ultrameter II CPFC^E water quality meter available from the MYRON L® Company (Carlsbad, CA, USA).

[00294] E. coli Detection Test Protocol: *E. coli* (colony forming units or CFUs) is measured for samples taken using the Urine and Wastewater Treatment System Sampling Procedure as

described herein. *E. coli* CFUs can be measured by any technique known in the art. Herein, a PETRIFILM™ *E. coli*/coliform count plate from 3M™ Company (St. Paul, MN, US) was used. The PETRIFILM™ plate contains modified violet red bile (VRB) nutrients, a cold-water soluble gelling agent, 5-bromo-4-chloro-3-indolyl-D-glucuronide (BCIG, an indicator of glucuronidase activity), and a tetrazolium indicator for facilitating colony enumeration.

[00295] The sample is blended or homogenized with an appropriate sterile diluent such as Butterfield's phosphate buffered dilution water, 0.1% peptone water, peptone salt diluent, quarter-strength Ringer's solution, 0.85-0.90% saline solution, bisulfite-free letheen broth, or distilled water.

[00296] The PETRIFILM™ plate is placed on a flat surface. A top film on the plate is lifted. 1 mL of sample suspension is dispensed on the center of the plate's bottom film, using a pipette held perpendicular to the inoculation area. The top film is rolled down onto the sample without trapping air bubbles. A 3M™ PETRIFILM™ Spreader is used to spread the inoculum over the entire plate growth area. The spreader is removed and the plate is left undisturbed for at least one minute, allowing a gel to form.

[00297] Following gel formation, the plate is incubated horizontally in a stack of no more than 20 plates. Incubation time can vary and the ordinarily-skilled artisan can select an incubation time appropriate to a given application based on instructions supplied by the manufacturer. Following incubation, colonies on the plates can be counted using a standard colony counter or another illuminated magnifier. Colonies appearing as blue to red-blue and associated with entrapped gas are to be counted as confirmed *E. coli*. Colonies should be counted within 1 hour of removal from the incubator or may be stored at -15 °C for up to one week prior to counting.

[00298] For extremely dense plates following incubation, the original sample may need to be diluted in order to obtain an accurate count, with appropriate volume corrections made based on the dilution volume.

[00299] SAMPLING PROCEDURES

[00300] Using the Test Protocols described above, various properties of the output of system components, such as water, liquids components, and the like can be characterized using samples prepared with the following sampling procedure.

[00301] Urine and Wastewater Treatment System Sampling Procedure: Any suitable extraction device can be used to obtain a liquid sample from the urine and wastewater treatment

system. For example, a syringe or volumetric pipette can be used to withdraw a specific volume of material, which may contain liquids and/or suspended solids, from the urine and wastewater treatment system. Alternatively, a greater volume of material than required by for analysis can be withdrawn into a sterile container and volume for testing can be measured separately. In an alternative aspect, a valve can be opened, allowing free flow of the liquid sample into a collection container. Samples collected in this manner can be used in any of the test protocols described herein.

CLAIMS

1. A non-sewered toilet system, comprising:

a frontend separation system comprising a solids separator, the frontend separation system configured to receive a combined waste and separate the combined waste into a separated solids portion and a separated liquid portion and the separated solids portion comprising mostly solids and some fluid and the separated liquid portion comprising mostly fluid with some solids, the combined waste comprising at least one of urine and feces;

a buffer tank separation system comprising: a liquids collection tank, a solids collection tank, and a belt separator, the belt separator positioned to receive an input stream comprising at least one of: the separated solids portion and the separated liquids portion from the frontend separation system, the belt separator configured further separate the input stream to deliver a solids portion of the input stream to the solids collection tank and to deliver the liquids portion of the input stream to the liquids collection tank;

a liquid waste treatment system configured to receive liquid waste collected in the liquids collection tank of the buffer tank separation system, comprising:

an ultra-filtration stage comprising an ultra-filtration filter configured to separate the liquid waste into a first permeate and a first concentrate, and

a reverse osmosis stage configured to receive a first permeate from the ultra-filtration stage and separate the first permeate into a second permeate and a second concentrate, the second permeate being a useable water; and

a solids waste treatment system configured to receive a feces slurry from the buffer tank separation system, the feces slurry comprising the solids waste collected in the solids collection tank, comprising:

an injector vessel;

a reactor configured to receive an injection of a slurry batch of the feces slurry from the injector vessel and an input of compressed air to be heated to a temperature over a heating time, the temperature being at or above the critical point of water into the super critical fluid phase; and

a combined concentrator and phase separator comprising:

a concentrator vessel configured to receive and contain a liquid to be concentrated; and

a separator configured to receive a treated output from the reactor and separate solid ash volume from liquid and gaseous effluent.

2. The system of claim 1, wherein the reactor of the solids waste treatment system is configured to maintain the slurry batch at a minimum temperature, within the reactor, for a predetermined treatment time to produce the treated output.
3. The system of claim 2, wherein the minimum temperature is greater than 374°C.
4. The system of claim 2, wherein the minimum temperature for treatment in the reactor ranges from about 350°C to about 450°C.
5. The system of claim 2, wherein the predetermined treatment time is about 150 s.
6. The system of claim 2, wherein the reactor is configured to maintain a pressure of about 220 bar within the reactor for the predetermined treatment time.
7. The system of claim 1, further comprising an injection pressure vessel configured to deliver the input of compressed air to the reactor, the input of compressed air being a volume of compressed air with an amount of oxygen for a subsequent wet oxidation of the slurry batch.
8. The system of claim 1, wherein the separator of the combined concentrator and phase separator is configured as a heat exchanger to utilize heat from the treated output to heat a heating surface of a heat exchange portion of the separator that extends into or around the concentrator vessel to heat the liquid contained therein.
9. The system of claim 1, wherein the combined concentrator and phase separator comprises a blower and a plurality of discs, the plurality of discs arranged about an axle and housed within the concentrator vessel configured to be rotated through the contained liquid to wet said discs, the blower positioned to direct air into the concentrator vessel toward the plurality of discs to evaporate liquid from the wet discs.
10. The system of claim 1, further comprising a drying tunnel comprises a dryer belt housed in a contained air duct system configured to force air toward the dryer belt.

11. The system of claim 10, wherein the dryer belt is configured to receive and dry the solid ash volume.
12. The non-sewered toilet system of claim 1, wherein the buffer tank separation system further comprises a homogenizer connected to a solids outlet of the solids collection tank, the homogenizer configured to receive the collected solids portion and form the feces slurry, the feces slurry being a uniform and homogenized slurry.
13. The non-sewered toilet system of claim 1, wherein the ultra-filtration stage comprises an ultra-filtration membrane filter, a first retention tank, and a first pump.
14. The non-sewered toilet system of claim 13, wherein the ultra-filtration stage is configured to deliver the first concentrate to the buffer tank separation system, the first concentrate comprising fluid rejected by the ultra-filtration filter.
15. The non-sewered toilet system of claim 1, wherein the reverse osmosis stage comprises a reverse osmosis filter, a second retention tank, and a second pump.
16. The non-sewered toilet system of claim 15, wherein the reverse osmosis stage is configured to deliver a second concentrate to the second retention tank.
17. The non-sewered toilet system of claim 1, wherein the concentrator vessel of the combined concentrator and phase separator of the solids waste treatment system is configured to receive a concentrate from the liquid waste treatment system and reduce the concentrate by heating and evaporation, forming a condensed effluent, the concentrate comprising fluid rejected by the reverse osmosis filter.
18. The non-sewered toilet system of claim 17, wherein the condensed effluent is delivered to a drying tunnel of the solids waste treatment system or a portion of the condensed effluent is delivered to the buffer tank separation system or both.
19. The non-sewered toilet system of claim 1, wherein at least a portion of the useable water produced by the liquid waste treatment system is used as flush water.
20. The non-sewered toilet system of claim 1, wherein the solids separator comprises:
a vacuum tank having a top portion, a base, and a cylindrical wall, the vacuum tank, comprising:

an inlet chamber formed within the vacuum tank at the top portion, the inlet chamber comprising an inlet and a chamber outlet;

a solids containment portion formed in the base of the vacuum tank and positioned centrally within the vacuum tank, the solids containment portion comprising a solids outlet, the solids containment portion configured to hold a separated solids portion of the combined waste;

a liquid containment portion formed in the base of the vacuum tank and contained within the vacuum tank surrounding the solids containment portion, the liquid containment portion comprising a liquids outlet, the liquid containment portion configured to hold a separated liquid portion of the combined waste portion;

a separating filter having a cylindrical tubular shape and extending from the chamber outlet to the solids containment portion, the separating filter forming a central separation volume within the vacuum tank; and

wherein the inlet chamber is configured to receive the combined waste via an inlet such that the combined waste is guided in a spiral about an interior surface of the inlet chamber and directed to the central separation volume, the liquid portion of the combined waste being allowed to flow through the separating filter to an outer portion surrounding the central separation volume and collect in the liquid containment portion of the base, the solids portion of the combined waste being contained within the central separation volume and collected in the solids containment portion of the base.

21. The non-sewered toilet system of claim 20, wherein, in the solids separator, the separating filter comprises a plurality of profile wires, each of the profile wires having a specified cross-section, the plurality of profile wires are arranged at a regular interval to form a plurality of grooves extending from slits between the profile wires at an inner circumference of the cylindrical tubular shape to wider openings at an outer circumference of the cylindrical tubular shape.

22. The non-sewered toilet system of claim 20, wherein, in the solids separator, the base of the vacuum tank has an inclined base within the liquid containment portion such that a flow of the liquid portion of the combined waste collected in the liquid containment portion of the base is directed to the liquids outlet.

23. The non-sewered toilet system of claim 20, wherein, in the solids separator, the solids containment portion is funnel or conical shaped to direct the solids portion of the combined waste to the solids outlet.
24. The non-sewered toilet system of claim 20, wherein, in the solids separator, the solids portion of the combined waste collected in the solids containment portion is released via the solids outlet after a pressure is applied to the vacuum tank.
25. The non-sewered toilet system of claim 20, wherein, in the solids separator, the liquid portion of the combined waste collected in the liquid containment portion is released via the liquids outlet by gravity.
26. The non-sewered toilet system of claim 20, wherein the solids separator further comprises a first actuator configured to operate a first valve at the solids outlet and a second actuator configured to operate a second valve the liquids outlet.
27. The non-sewered toilet system of claim 26, wherein, in the solids separator, the first valve is configured to open when an overpressure is applied to the vacuum tank, releasing the solids portion of the combined waste collected in the solids containment portion.
28. The non-sewered toilet system of claim 26, wherein, in the solids separator, the second valve is actuated after the first valve, releasing the liquid portion of the combined waste collected in the liquid containment portion.
29. The non-sewered toilet system of claim 1, wherein the frontend system further comprises a vessel configured to receive at least urine and feces and a flush tank configured to deliver a volume of flush water to the vessel to form a combined waste within the.
30. The non-sewered toilet system of claim 29, wherein a vacuum is applied to vacuum tank of the solids separator by a vacuum pump to evacuate the combined waste within the vessel.
31. The non-sewered toilet system of claim 29, further comprising a user interface configured for a user to select a flush mode comprising at least one of: a urine event mode and a defecation event mode.
32. The non-sewered toilet system of claim 1, wherein the buffer tank separation system further comprises at least one inlet configured to receive an input stream.

33. The non-sewered toilet system of claim 32, wherein the belt separator of the buffer tank separation system comprises a perforated belt looped between two rollers, the belt separator positioned to receive the input stream via the at least one inlet onto the perforated belt of the belt separator.
34. The non-sewered toilet system of claim 33, wherein the perforated belt of the belt separator comprises pores configured to allow the liquids portion of the input stream to pass through to the liquids collection tank and to retain the solids portion on the perforated belt.
35. The non-sewered toilet system of claim 33, wherein the buffer tank separation system further comprises a squeegee configured to remove the solids portion of the input stream from the perforated belt of the belt separator.
36. The non-sewered toilet system of claim 1, wherein the buffer tank separation system further comprises a liquid deflector positioned beneath the belt separator configured to direct at least some of the liquids portion of the input stream to the liquids collection tank.
37. The non-sewered toilet system of claim 1, wherein the liquids collection tank of the buffer tank separation system further comprises a sludge outlet and a bottom wall configured to direct a sludge stream to the sludge outlet, the sludge stream comprising solids settled from the liquids portion contained in the liquids collection tank.
38. The non-sewered toilet system of claim 1, wherein the solids collection tank of the buffer tank separation system further comprises an overflow outlet.
39. The non-sewered toilet system of claim 32, wherein, in the buffer tank separation system, the at least one inlet comprises a solids inlet configured to receive a mostly solids input stream comprising feces, the solids inlet comprising a chamber, an offset chamber inlet, and a chamber outlet, the chamber shaped such that the solids input stream received via the offset chamber inlet is directed toward an interior wall surface of the chamber to flow out the chamber outlet onto the belt separator.
40. The non-sewered toilet system of claim 32, wherein, in the buffer tank separation system, the at least one inlet comprises a liquids inlet configured to receive and direct a mostly liquids input stream onto the belt separator.

41. The non-sewered toilet system of claim 32, wherein, in the buffer tank separation system, the at least one inlet comprises one or more auxiliary input ports configured to receive at least one of: a urine stream comprising mostly urine, a sludge stream received from the liquids collection tank, an overflow stream received from the solids collection tank, a reject stream received from a liquids treatment system, a filtrate received from a feces treatment system, and a condensed effluent received from a feces treatment system.

42. The non-sewered toilet system of claim 33, wherein the buffer tank separation system further comprises a motor configured to drive at least one of the two rollers of the belt separator.

43. The non-sewered toilet system of claim 1, wherein the liquid waste treatment system further comprises a diffuser positioned at an inlet to the ultra-filtration filter, the diffuser connected to an air blower and configured to introduce air into the liquid waste to reduce the density of the liquid waste and to generate a crossflow within the ultra-filtration filter.

44. The non-sewered toilet system of claim 43, wherein, in the liquid waste treatment system, the diffuser comprises an air stone.

45. The non-sewered toilet system of claim 1, wherein the ultra-filtration stage of the liquid waste treatment system comprises a first pump configured to deliver the first permeate to a first retention tank.

46. The non-sewered toilet system of claim 1, the reverse osmosis stage of the liquid waste treatment system comprises a second pump configured to deliver the second permeate to a second retention tank.

47. The non-sewered toilet system of claim 46, wherein the second pump is configured to operate at a high pressure.

48. The non-sewered toilet system of claim 46, wherein the second pump is configured to operate at a pressure of about 30 to 35 bar.

49. The non-sewered toilet system of claim 1, wherein the second permeate discharged as the useable water is a non-potable water for use or re-use from the liquid waste treatment system meets at least one of:

chemical oxygen demand (COD) $\leq$ 50 mg/L;

total suspended solids (TSS) ≤ 10 mg/L;

total Nitrogen (N) $> 70\%$ reduction relative to the total N in the liquid waste received into the UF stage;

total Phosphorus (P) $> 80\%$ reduction relative to the total P in the liquid waste received into the UF stage; and

E. coli ≤ 100 per L.

50. The non-sewered toilet system of claim 1, wherein, in the liquid waste treatment system, the ultra-filtration stage operates at a first pressure and the reverse osmosis stages operate at a second pressure.

51. The non-sewered toilet system of claim 50, wherein, in the liquid waste treatment system, the reverse osmosis stage operates at a high pressure.

52. The non-sewered toilet system of claim 1, wherein, in the liquid waste treatment system, a controller enables automated operation of the ultra-filtration stage and the reverse osmosis stage.

53. The non-sewered toilet system of claim 1, wherein a controller enables automated operation of at least one of: the frontend separation system, the buffer tank separation system, the liquid waste treatment system, and the solids waste treatment system.

54. The non-sewered toilet system of claim 1, wherein at least the solids separator, the buffer tank separation system, the liquid waste treatment system, and the solids waste treatment system are housed in a single unit.

55. A method for treatment of human waste, the method comprising:

receiving, into a frontend separation system, a human waste comprising at least one of urine and feces;

separating the human waste into at least one of a mostly liquid stream and a mostly solids stream;

delivering the mostly liquid stream from the frontend separation system to a buffer tank separation system;

receiving the mostly liquid stream via a first inlet onto a belt separator and separating at least some of the solids from the mostly liquid stream;

depositing the solids separated from the mostly liquid stream into the solids collection tank and deposit the remaining portion of the mostly liquid stream into a liquids collection tank for short-term storage and passive separation of liquid from remaining solid waste received into the liquids collection tank;

delivering the mostly solids stream from the frontend separation system to the buffer tank separation system;

receiving the mostly solids stream via a second inlet onto the belt separator and separating most of the solids from the mostly solids stream;

depositing the solids separated from the mostly solids stream into the solids collection tank and deposit the remaining portion of the mostly solids stream into the liquids collection tank for short-term storage and passive separation of liquid from remaining solid waste received into the liquids collection tank;

separating pathogens from a liquid waste received from a volume of collected liquids separated within the liquids collection tank in a urine and wastewater treatment system;

delivering a volume of collected solids settled within the solids collection tank to a homogenizer to form a feces slurry;

inactivating pathogens in the feces slurry in a water oxidation solids treatment system.

56. The method of claim 55, wherein inactivating pathogens in the feces slurry comprises:

receiving a slurry batch of feces into an injector of the water oxidation solids treatment system;

pressurizing the slurry batch with air;

injecting the slurry batch into a reactor;

heating the slurry batch, within the reactor, to a temperature over a heating time, the temperature being over the temperature of the critical point of water into the super critical fluid phase;

maintaining the slurry batch at a minimum temperature, within the reactor, for a predetermined treatment time to produce a treated output, wherein the minimum temperature is greater than the critical point of water;

ejecting the treated output into a phase separator of the water oxidation solids treatment system;

separating the treated output into a solid ash volume, a liquid waste, and a gaseous effluent; and

transporting the solid ash volume to a disposal bin for removal.

57. The method of claim 56, wherein injecting the slurry batch into the reactor further comprises providing the reactor with an amount of oxygen for a subsequent wet oxidation.

58. The method of claim 56, wherein the temperature is a temperature above a wet oxidation ignition temperature.

59. The method of claim 56, further comprising receiving a liquid to be concentrated into a concentrator of the water oxidation solids treatment system.

60. The method of claim 56, wherein receiving a slurry batch of feces further comprises homogenizing the slurry batch prior to receiving the slurry batch into the injector.

61. The method of claim 56, further comprising discharging off-gasses and liquid waste from the combined concentrator and phase separator the water oxidation solids treatment system.

62. The method of claim 56, wherein the minimum temperature for treatment in the reactor ranges from about 350°C to about 450°C.

63. The method of claim 56, wherein the predetermined treatment time is about 150 s.

64. The method of claim 56, wherein maintaining the slurry batch at the minimum temperature comprises maintaining a pressure within the reactor for the predetermined treatment time.

65. The method of claim 56, wherein the critical point of water is 374°C.

66. The method of claim 55, wherein the mostly liquid stream is less than 5% dry solids content by volume and the mostly solids stream is about 1% to about 25% dry solid contents by volume.

67. The method of claim 55, further comprising:

receiving a liquid waste comprising the volume of collected liquids separated within the liquids collection tank to a urine and wastewater treatment system;

blowing air into the liquid waste to reduce the density of the liquid waste and to generate crossflow;

filtering the liquid waste in an ultra-filtration stage to separate a first permeate and a first concentrate;

discharging the first concentrate to the buffer tank separation system;

filtering the first permeate in a reverse osmosis stage to separate a second permeate and a second concentrate;

recirculating the second concentrate to filter in the reverse osmosis stage; and

discharging the second permeate as useable water.

68. The method of claim 67, wherein the second permeate discharged as useable water meets at least one of:

chemical oxygen demand (COD) ≤ 50 ;

total suspended solids (TSS) ≤ 10 mg/L;

total Nitrogen (N) $> 70\%$ reduction relative to the total N of the liquid waste received into the ultra-filtration stage;

total Phosphorus (P) $> 80\%$ reduction relative to the total P of the liquid waste received into the ultra-filtration stage; and

E. coli ≤ 100 per L.

69. The method of claim 67, further comprising:

delivering a volume of the second concentrate to a concentrator of the water oxidation solids treatment system; and

heating the volume of the second concentrate forming a condensed effluent by evaporation.

70. The method of claim 67, wherein the reverse osmosis stages operates at a high pressure.

71. The method of claim 55, wherein separating the human waste into at least one of a mostly liquid stream and a mostly solids stream comprises:

receiving a human waste into a vessel having a main outlet, the human waste comprising at least one of: urine and feces;

receiving a volume of flush water forming a combined waste within the vessel;

evacuating the combined waste through the main outlet of the vessel into the solids separator; and

separating the combined waste into a liquid portion comprising mostly fluid with some solids and a solids portion comprising mostly solids and some fluid.

72. The method of claim 71, wherein evacuating the combined waste comprises: using a vacuum pump to form a weak vacuum to transport the combined waste to the solids separator.

73. The method of claim 71, wherein the combined waste is received into the inlet chamber of the solids separator via the inlet, the inlet being positioned to receive the combined waste tangentially and direct the combined waste along a circumferential interior wall of the inlet chamber to decelerate the combined waste.

74. The method of claim 71, wherein the solids portion of the combined waste collected in the solids containment portion is released via the solids outlet after a pressure is applied to the vacuum tank.

75. The method of claim 71, wherein the liquid portion separated from the combined waste comprises less than 5% dry solids content, the dry solids content comprising at least one of feces and toilet paper.

76. The method of claim 71, wherein the solids portion separated from the combined waste comprises about 1%-25% dry solids content, the solids content comprising at least one of feces and toilet paper.

77. The method of claim 71, wherein the volume of flush water comprises a predetermined amount of flush water based on whether the human waste received is due to a urination event or a defecation event.

78. The method of claim 55, wherein, in the buffer tank separation system, the method comprises:

receiving, onto a belt separator, an input stream comprising at least one of: solids and liquids;

separating, by the belt separator, the input stream into a solids portion and a liquids portion;

delivering the liquids portion to a liquids collection tank for sedimentation;

delivering the solids portion to a solids collection tank.

79. The method of claim 78, wherein the input stream comprises at least one of: a mostly liquids input stream, a mostly solids input stream comprising feces, a urine stream comprising mostly urine, a sludge stream received from the liquids collection tank, an overflow stream received from the solids collection tank, a reject stream received from a liquids treatment system, a filtrate received from a feces treatment system, and a condensed effluent received from a feces treatment system.

80. The method of claim 79, wherein, when the input stream is a mostly solids input stream comprising feces, the input stream is received via a solids inlet comprising a chamber, an offset chamber inlet, and a chamber outlet, the chamber shaped such that the solids input stream received via the offset chamber inlet is directed toward an interior wall surface of the chamber to flow out the chamber outlet onto the belt separator.

81. The method of claim 78, wherein the belt separator comprises a perforated belt looped between two rollers, the belt separator positioned to receive an input stream comprising at least one of: solids and liquids, the input stream received via the at least one inlet onto the belt of the belt separator, the belt separator configured to deliver the solids portion of the input stream to the solids collection tank and to deliver the liquids portion of the input stream to the liquids collection tank.

82. The method of claim 78, wherein the perforated belt of the belt separator comprises pores configured to allow the liquids portion of the input stream to pass through to the liquids collection tank and to retain the solids portion on the perforated belt.

83. The method of claim 78, wherein delivering the solids portion to the solids collection tank comprises removing the solids portion of the input stream from the perforated belt of the belt separator with a squeegee.

84. The method of claim 78, wherein delivering the liquids portion to a liquids collection tank for sedimentation comprises directing at least some of the liquids portion of the input stream to the liquids collection tank via a liquid deflector positioned beneath the belt separator.
85. The method of claim 78, further comprising releasing a collected liquids portion from the liquids collection tank to a liquids treatment system.
86. The method of claim 78, further comprising delivering a sludge portion from the liquids collection tank to the belt separator via a sludge outlet.
87. The method of claim 78, further comprising delivering an overflow portion from the solids collection tank to the belt separator via an overflow outlet.
88. The method of claim 78, further comprising forming, in a homogenizer, a uniform and homogenized slurry from a collected solids portion output from the solids collection tank.
89. The method of claim 88, further comprising releasing the slurry to a feces treatment system.
90. The method of claim 67, further comprising pumping the first permeate to a reservoir tank.
91. The method of claim 90, further comprising pumping the first permeate from the reservoir tank through the reverse osmosis stage at a high pressure.
92. The method of claim 67, further comprising recirculating the second concentrate to filter in the reverse osmosis stage.
93. The method of claim 67, wherein the liquid waste comprises at least one of urine, feces, rinse water, and trace toilet incidentals.
94. The method of claim 67, wherein the liquid waste is a clarified liquid received from a buffer tank system.
95. The method of claim 67, wherein discharging the first concentrate comprises discharging the first concentrate to a system for separation of solid waste in concentrate.
96. The method of claim 67, wherein filtering the first permeate in the reverse osmosis stage comprises receiving the first permeate in a reservoir tank and recirculating the second concentrate.

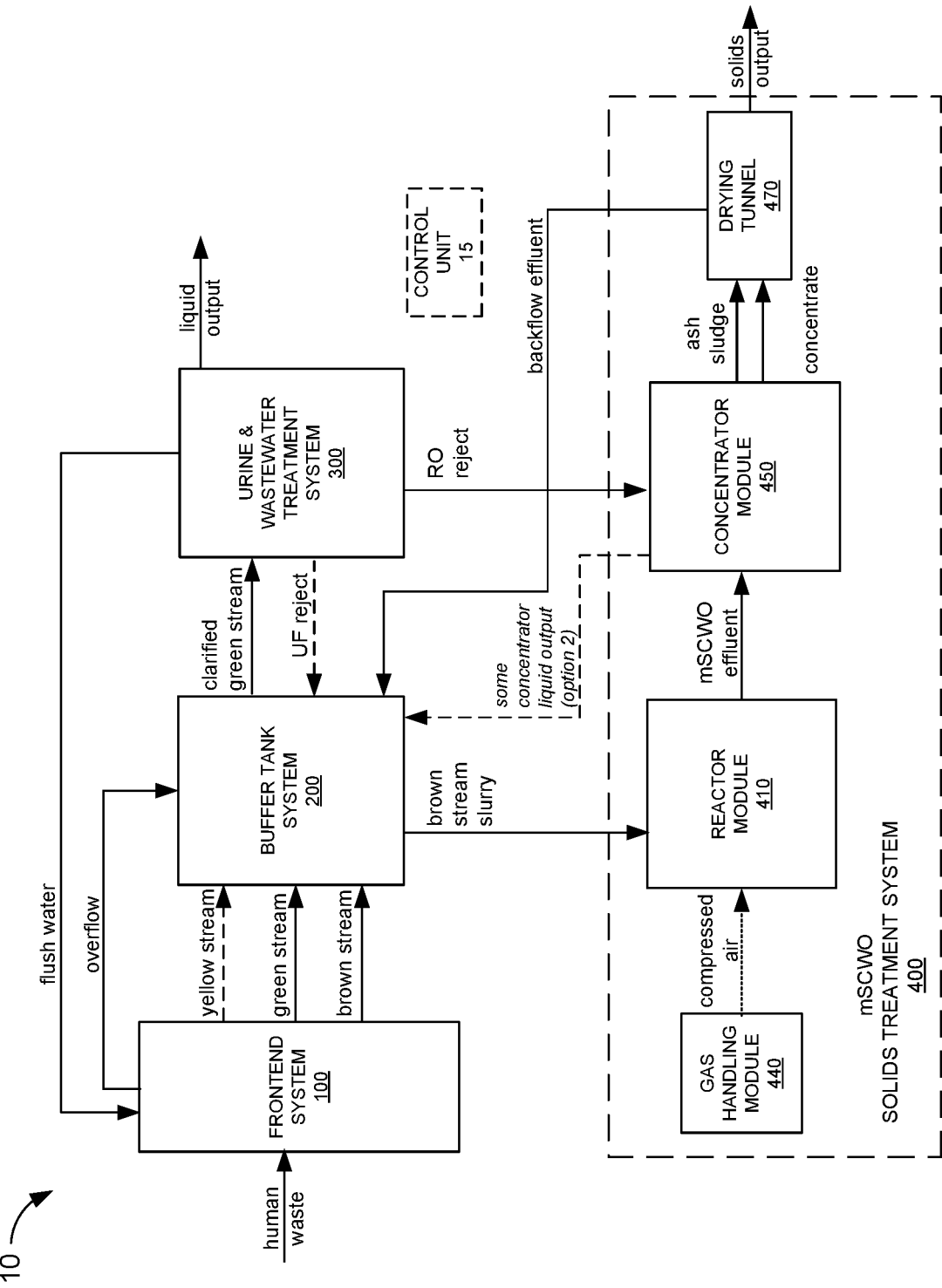


FIG. 1

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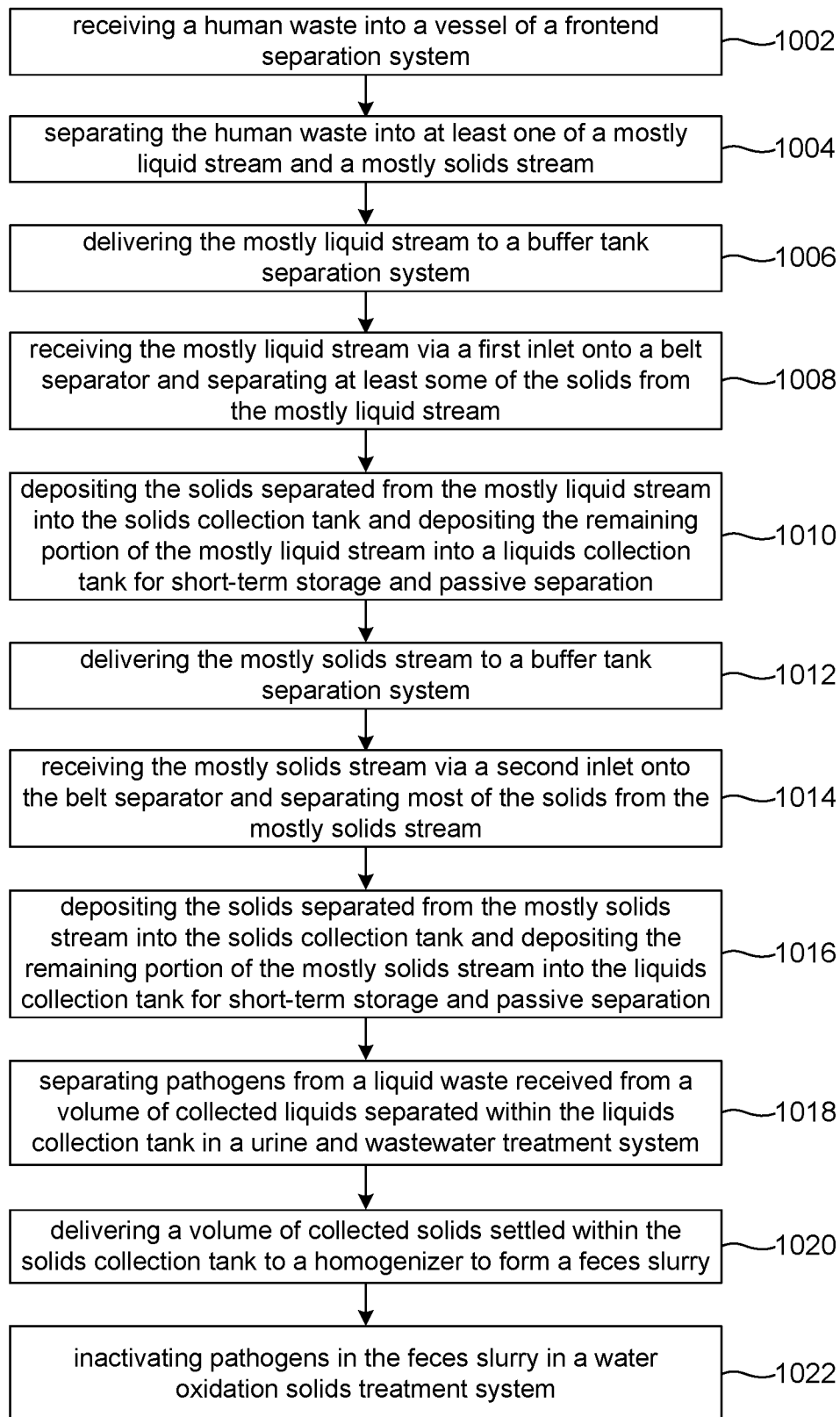
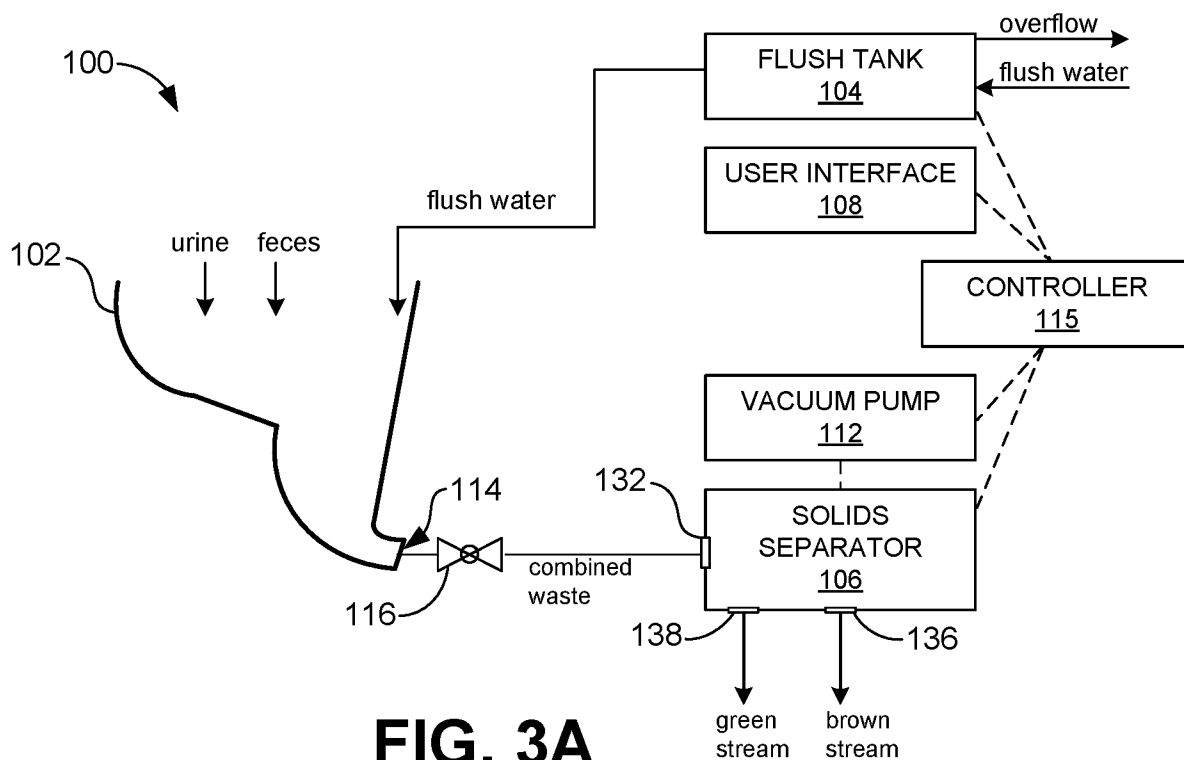
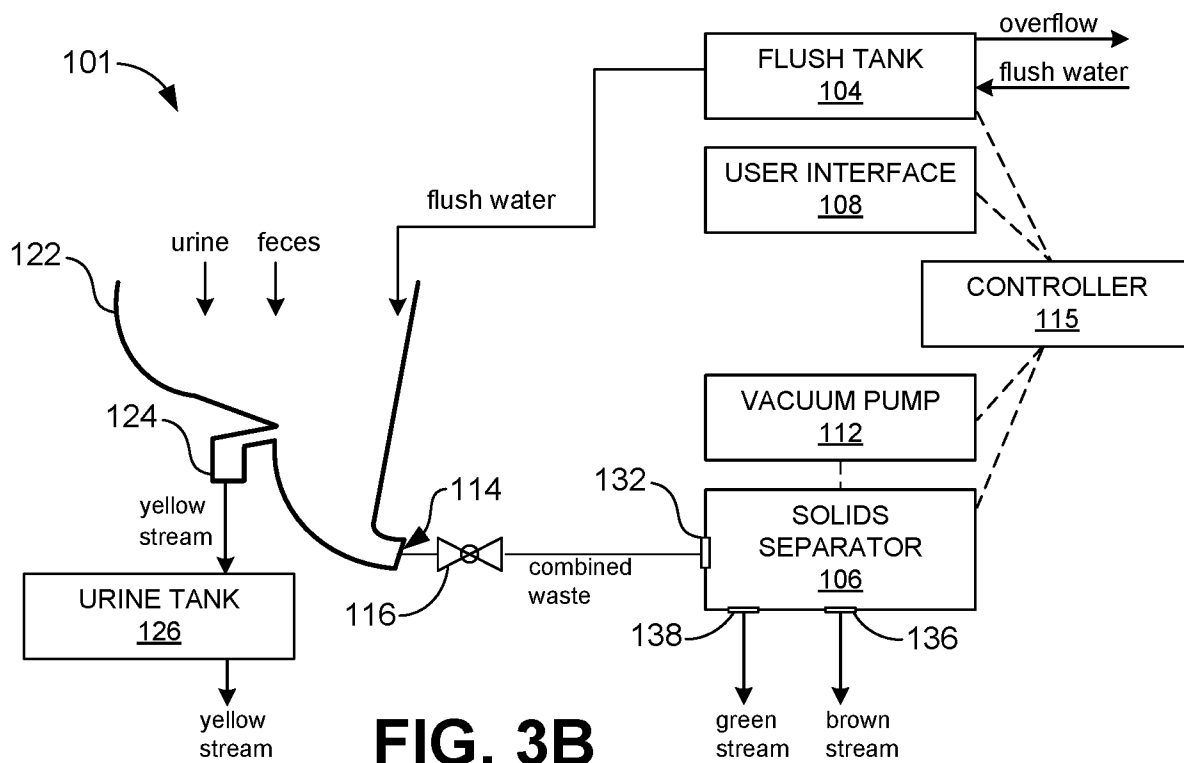


FIG. 2

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**FIG. 3A****FIG. 3B**

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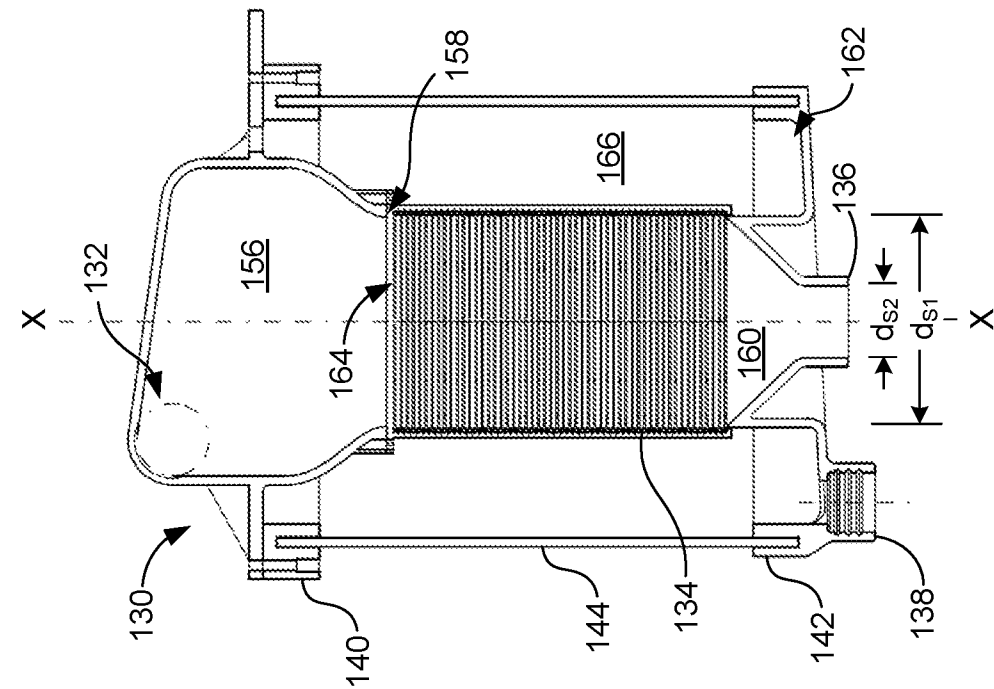


FIG. 5

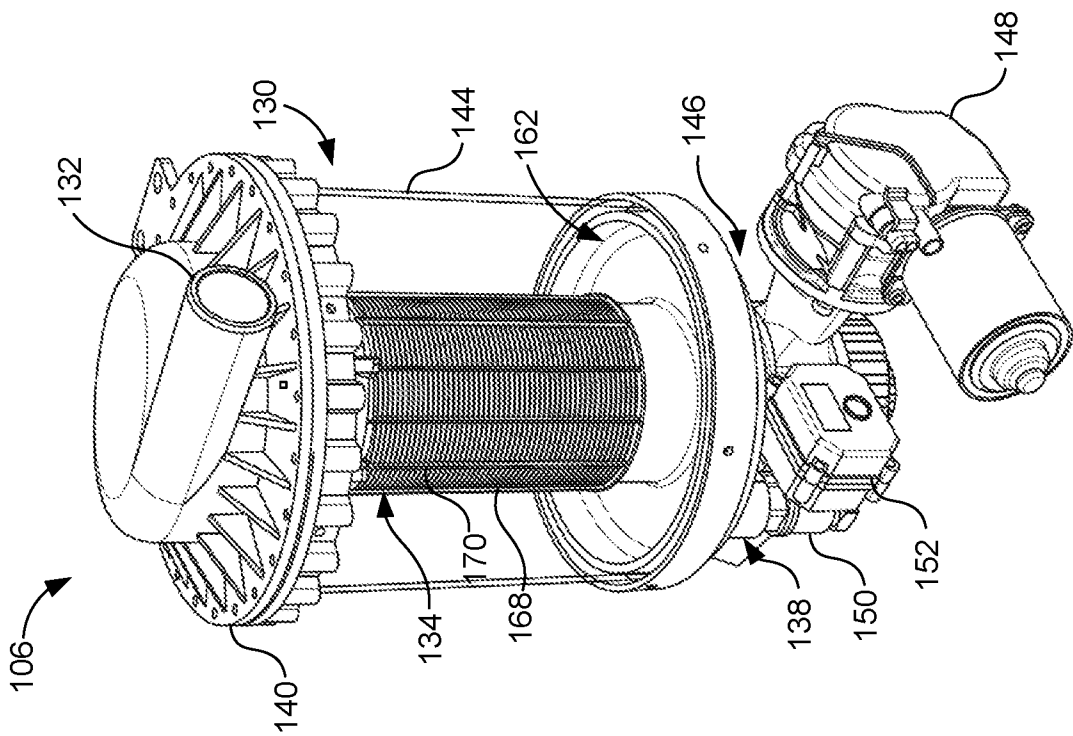
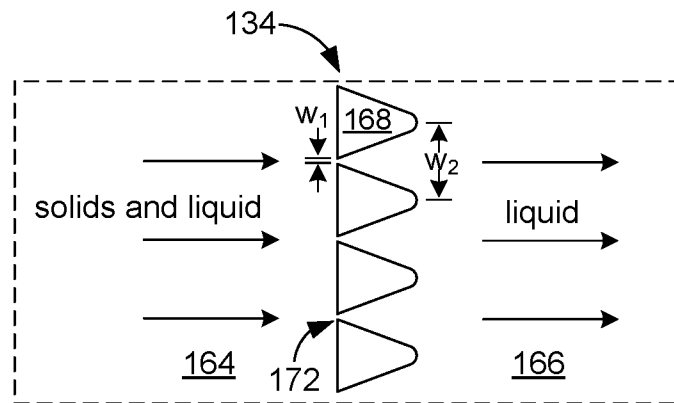
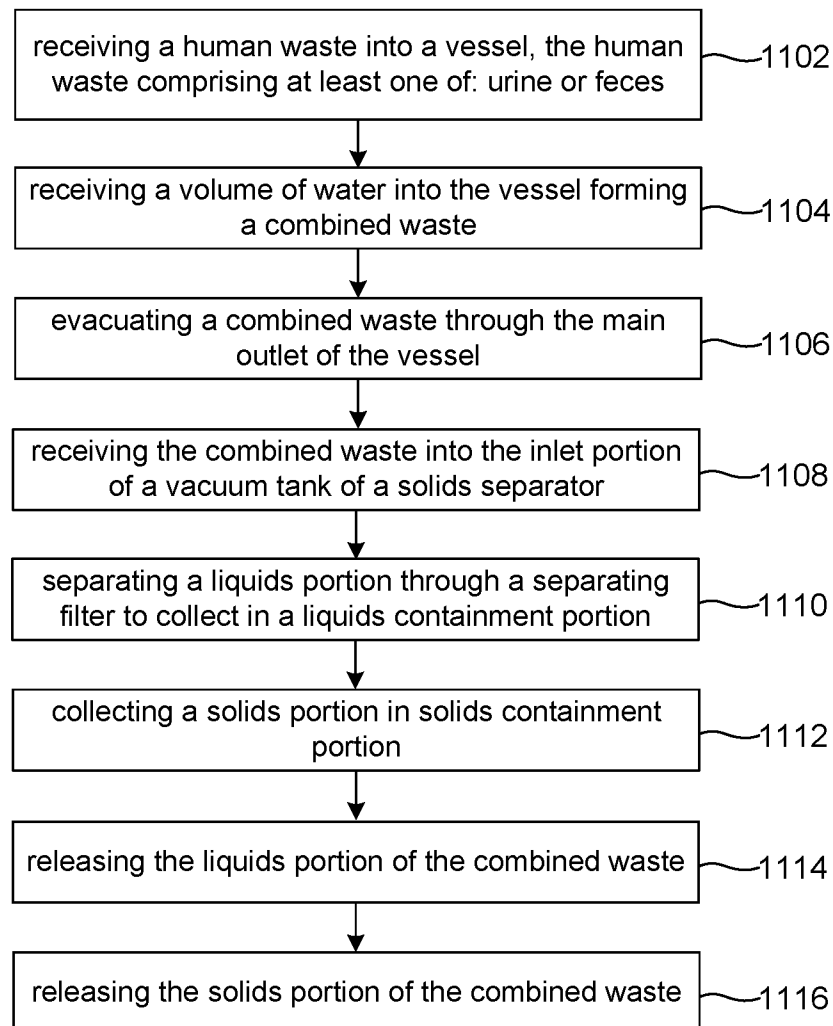
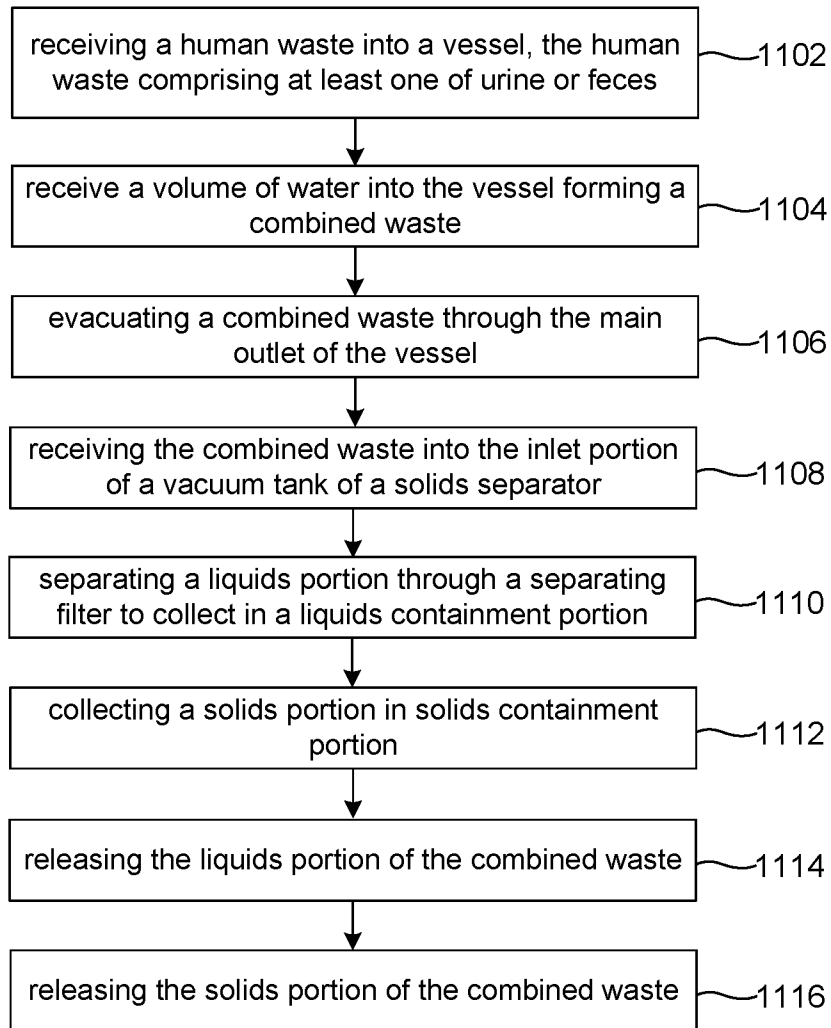


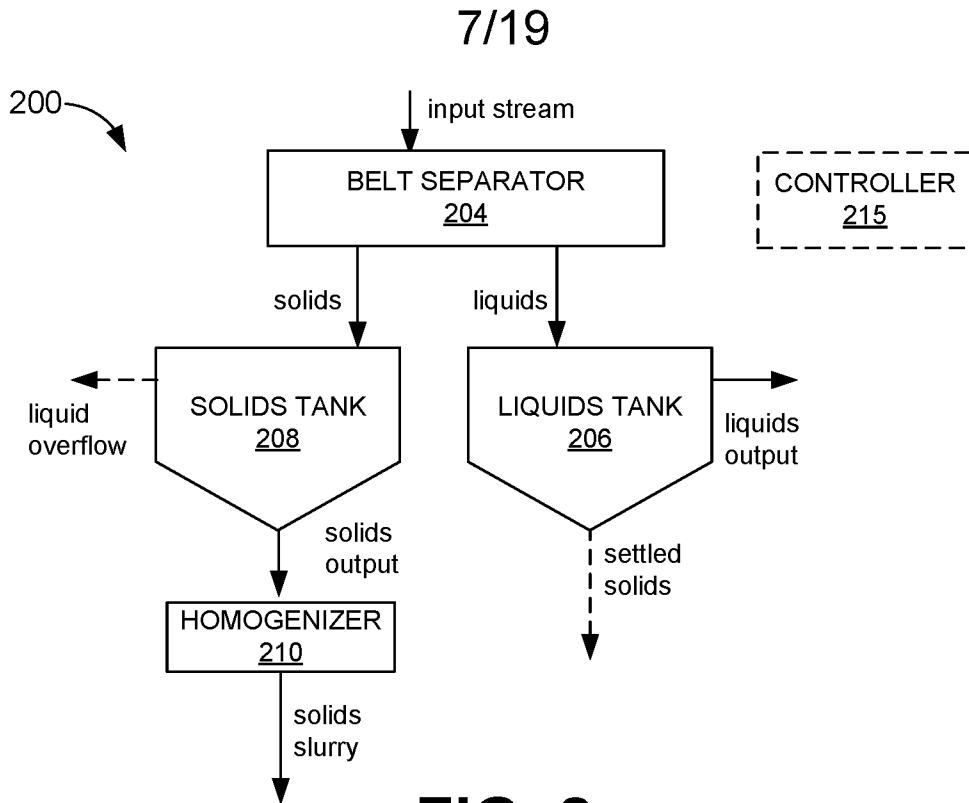
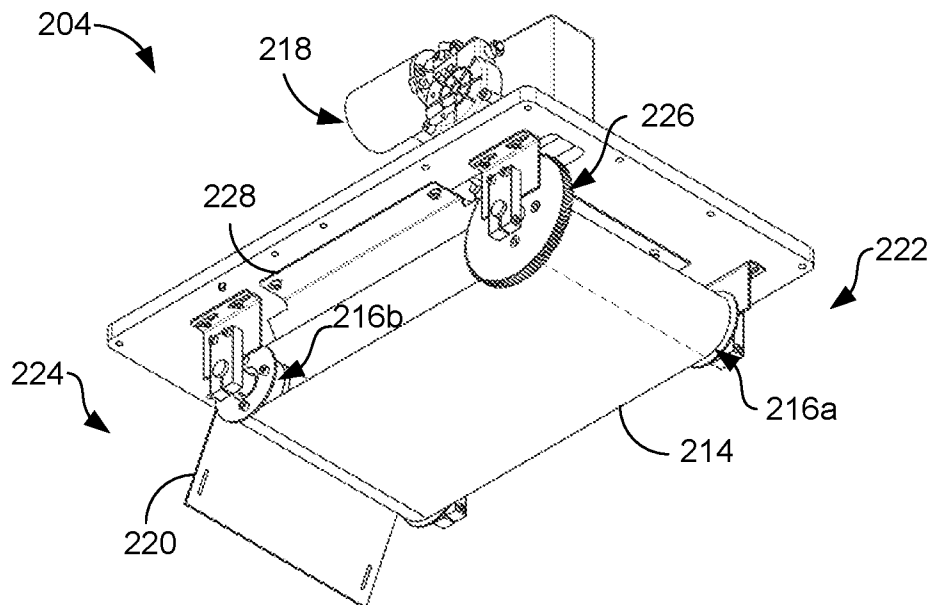
FIG. 4

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**FIG. 6****FIG. 7**

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**FIG. 7**

**FIG. 8****FIG. 9A**

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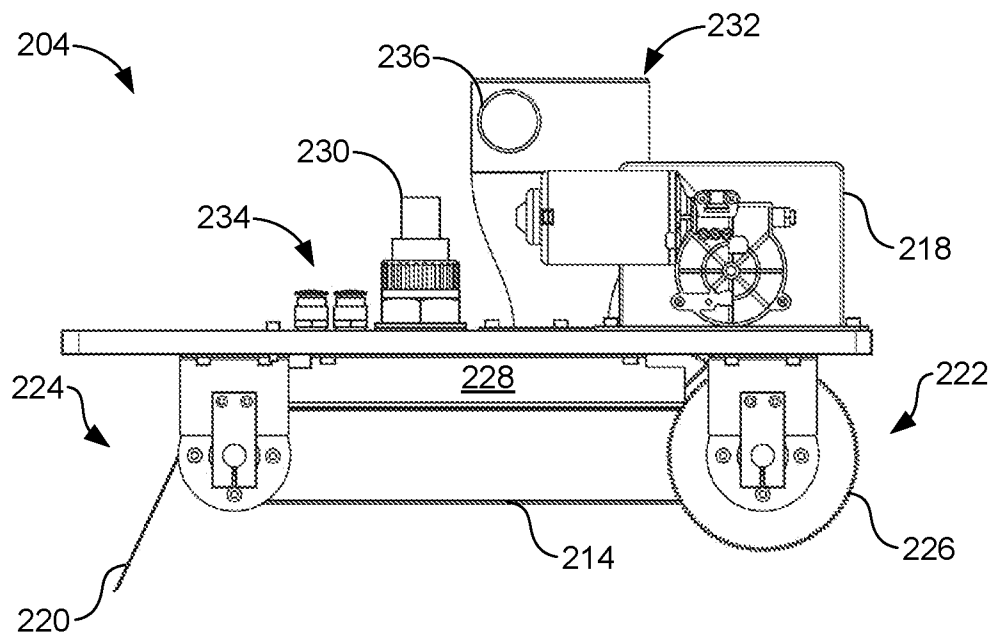


FIG. 9B

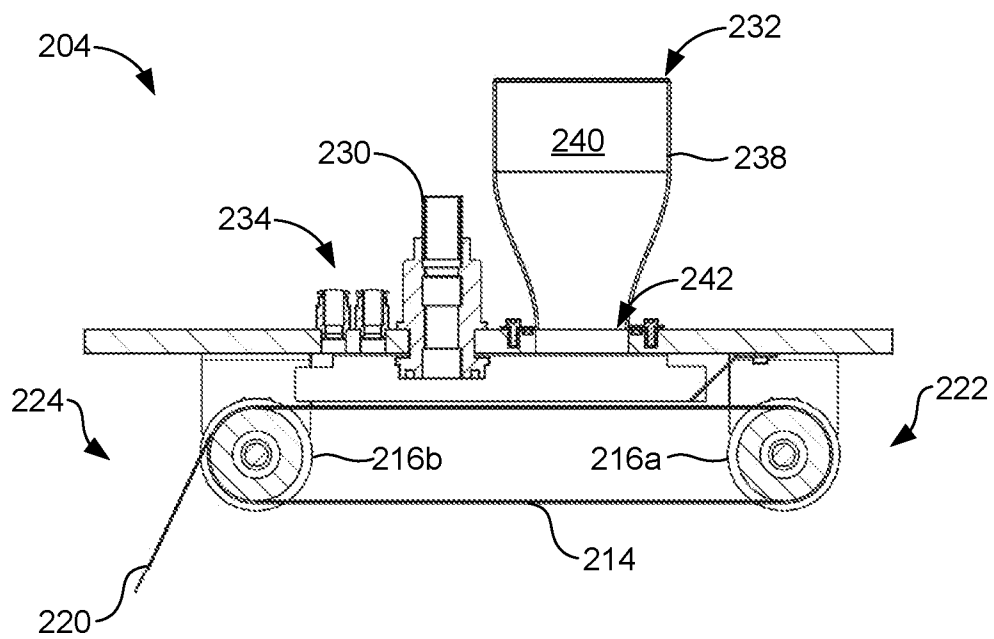


FIG. 9C

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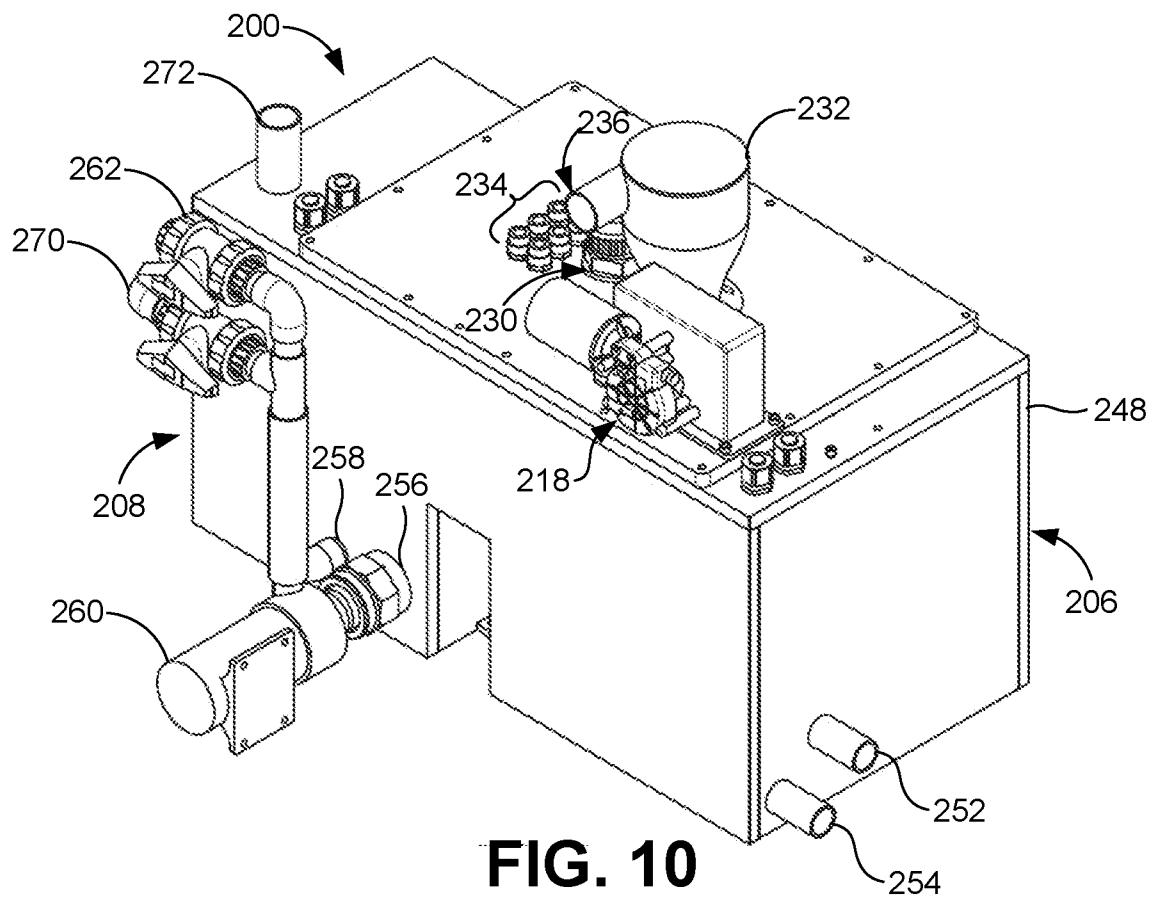


FIG. 10

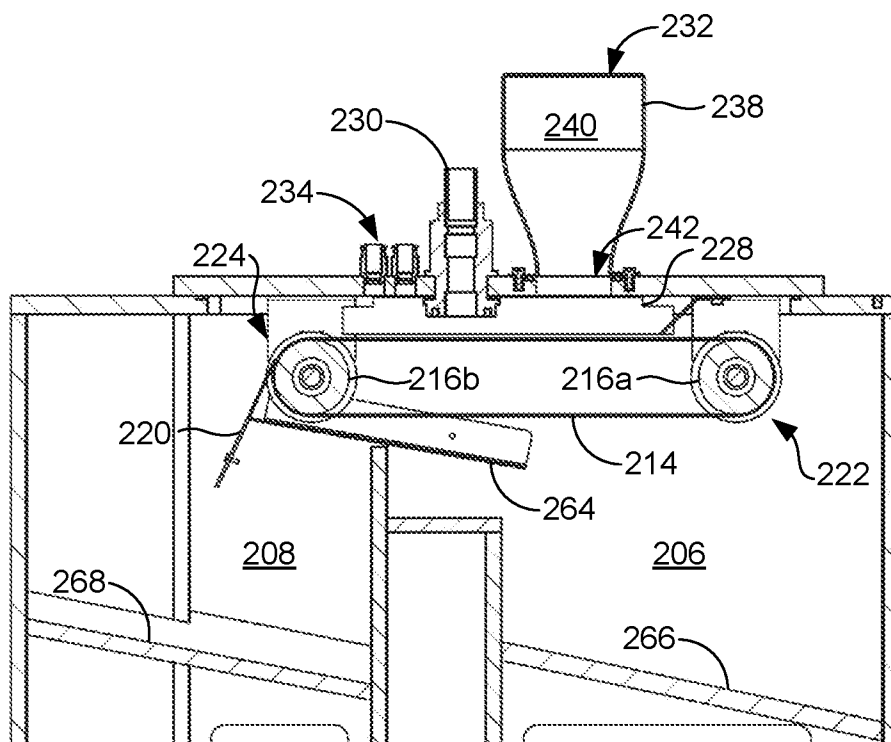


FIG. 11

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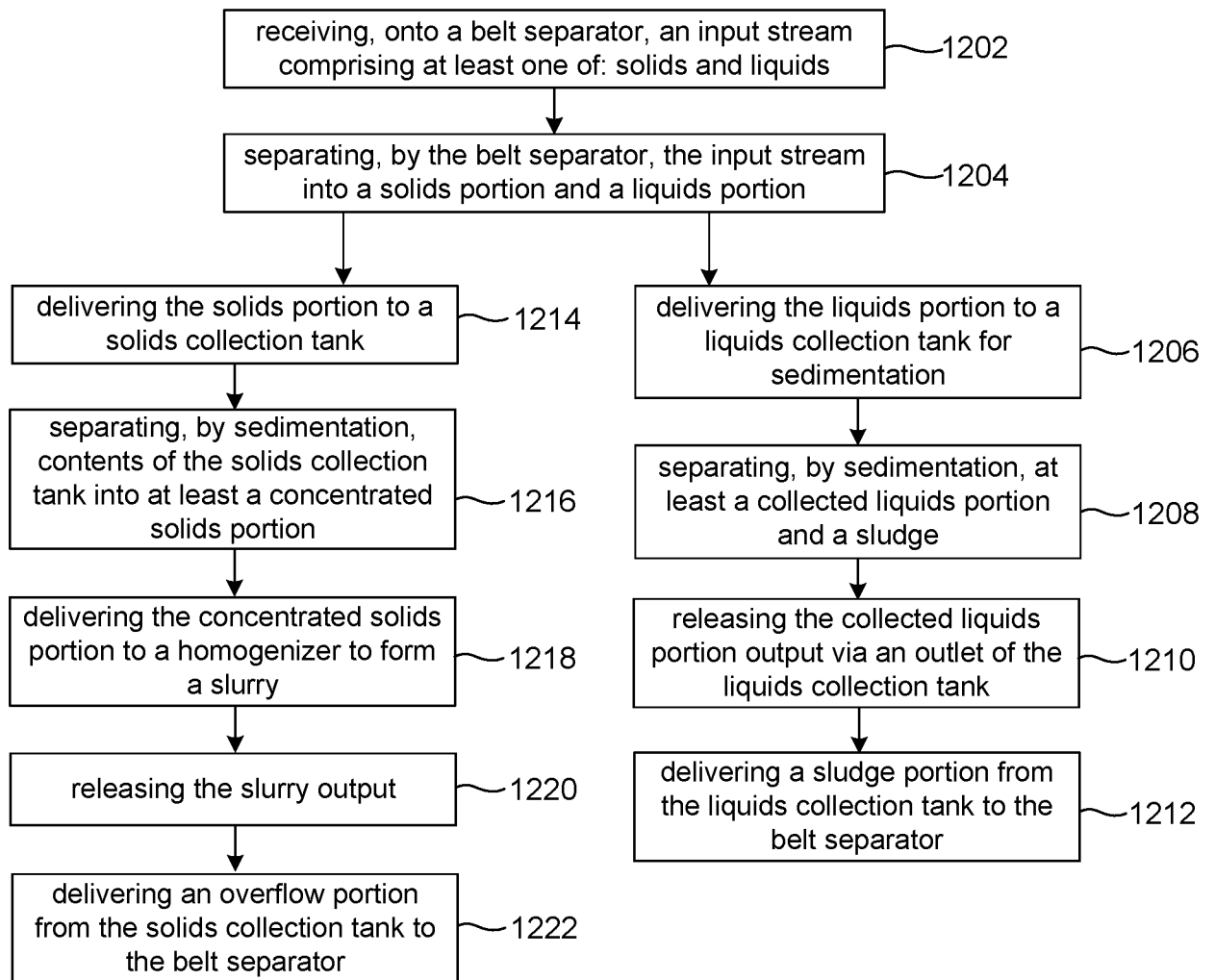


FIG. 12

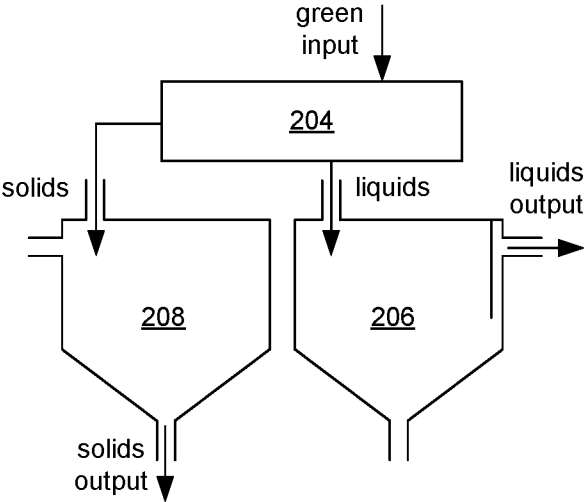


FIG. 13A

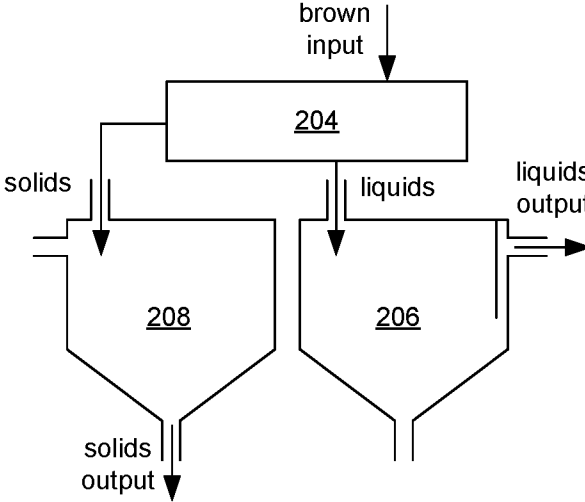


FIG. 13B

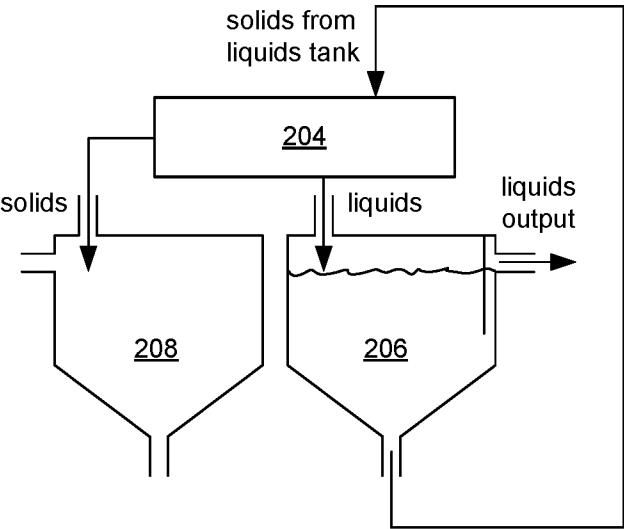


FIG. 13C

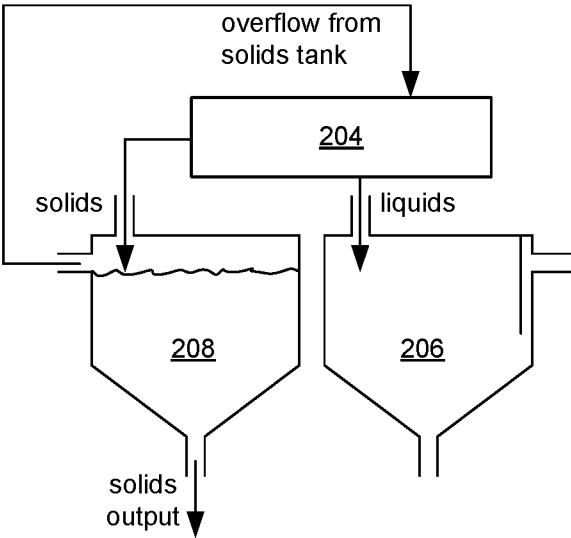


FIG. 13D

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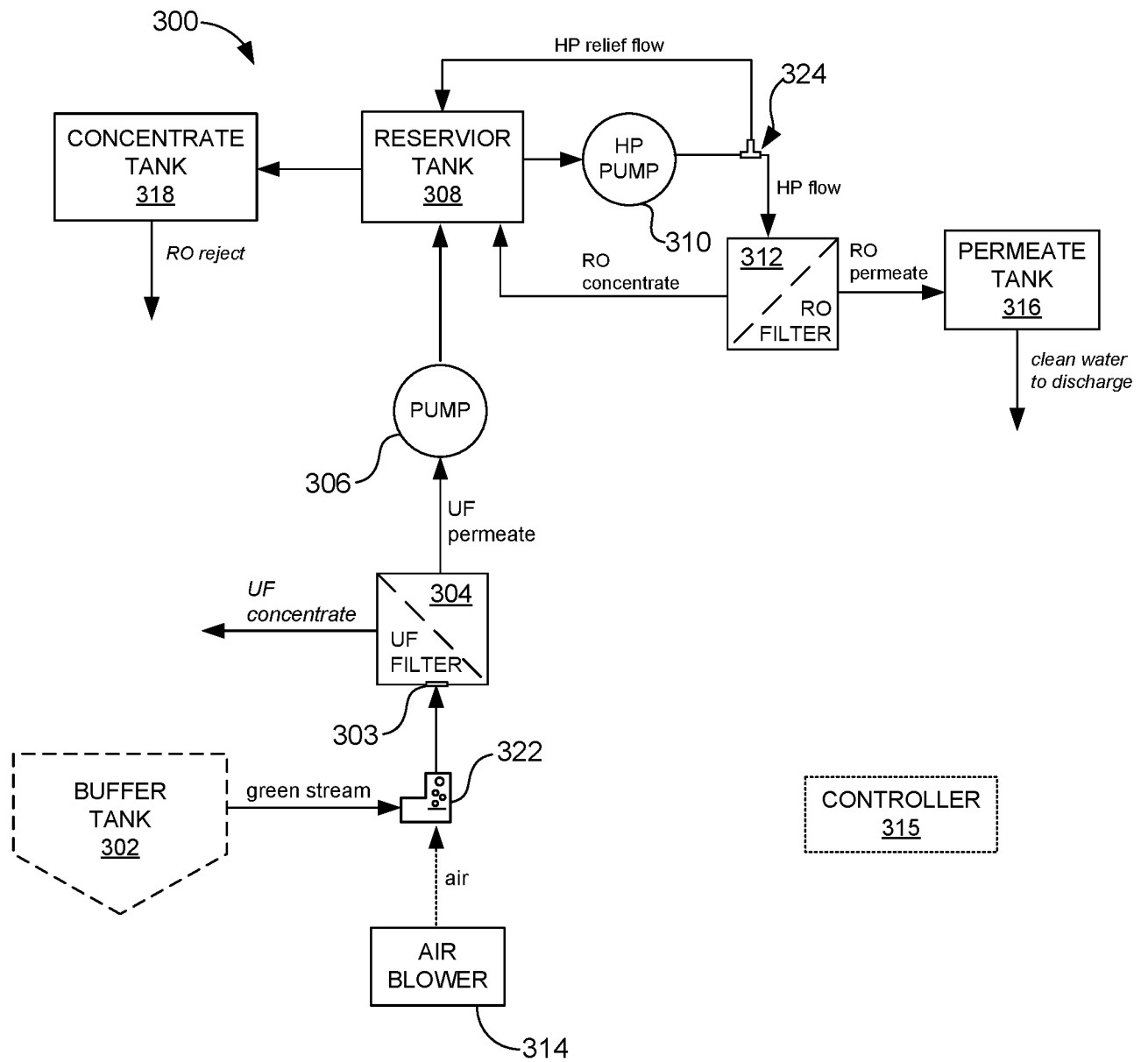


FIG. 14

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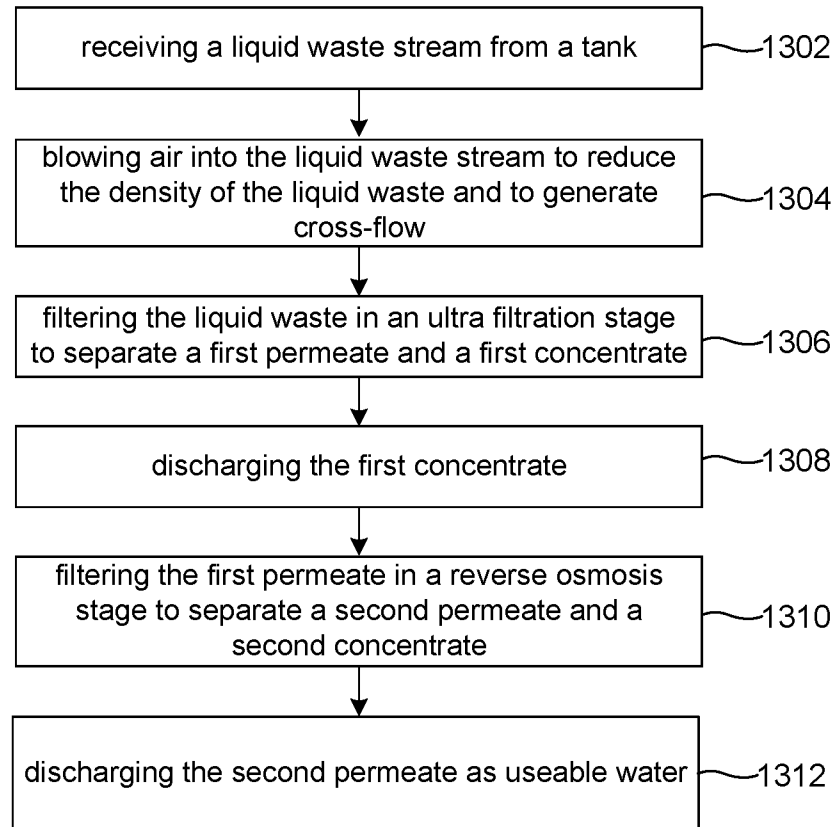


FIG. 15

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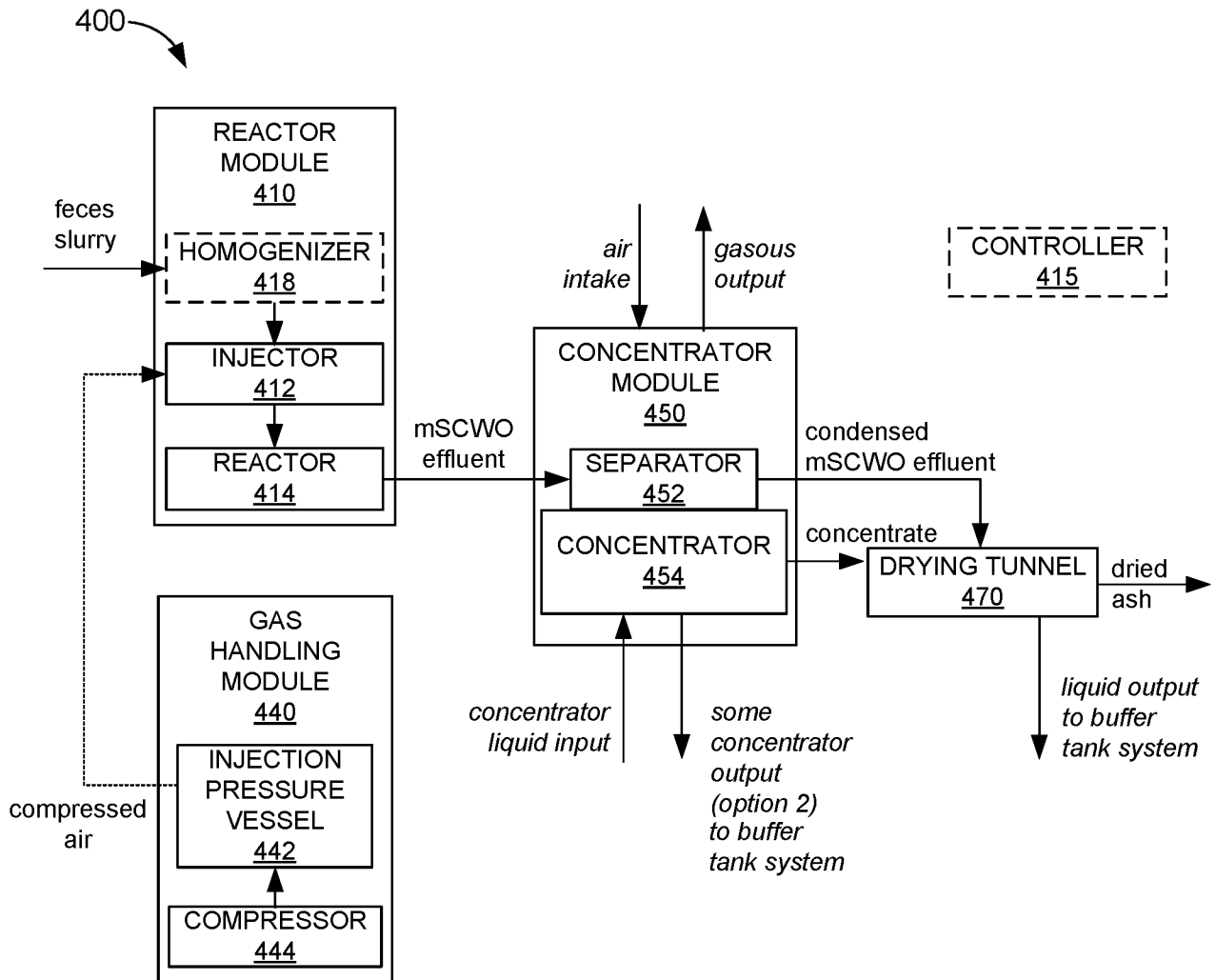


FIG. 16

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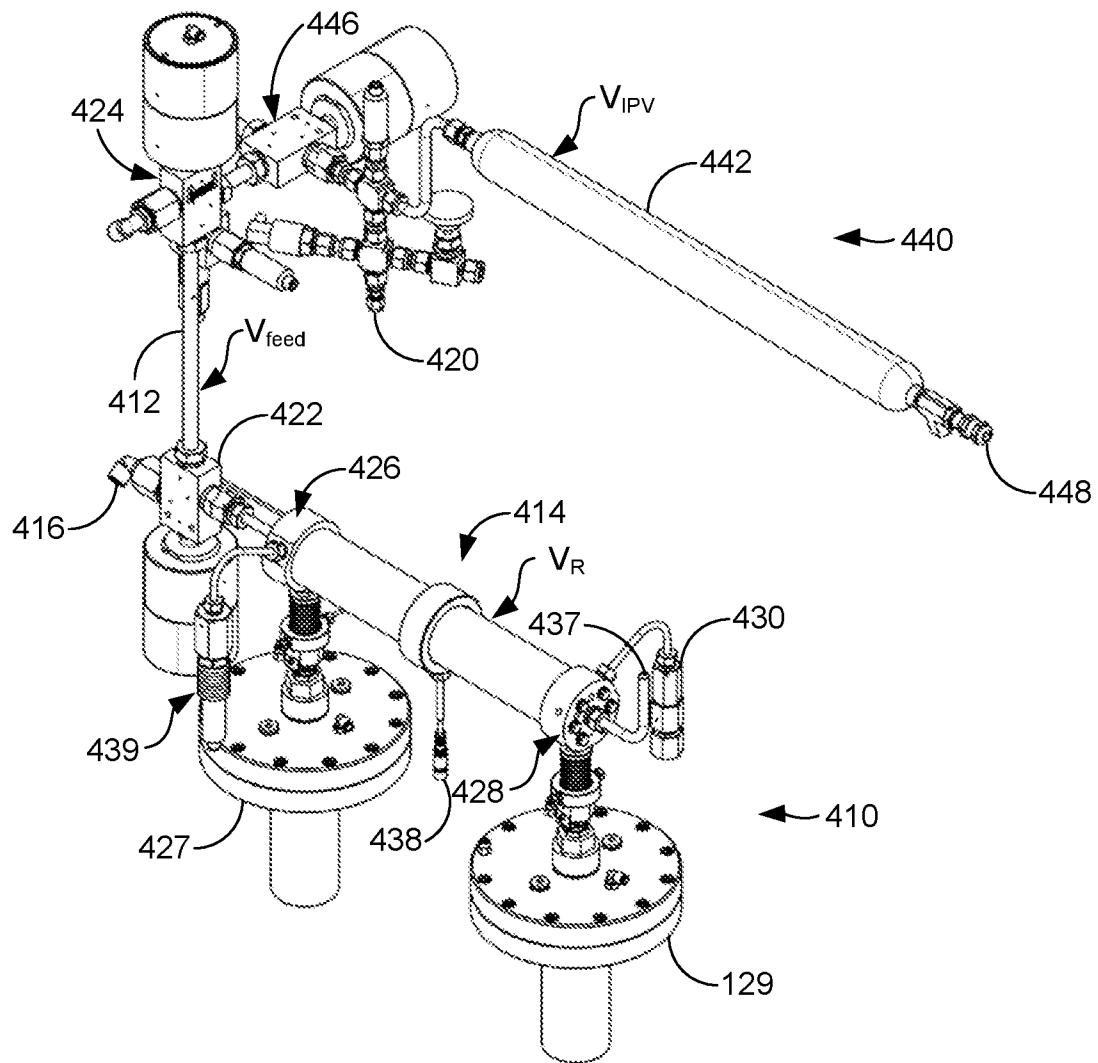


FIG. 17

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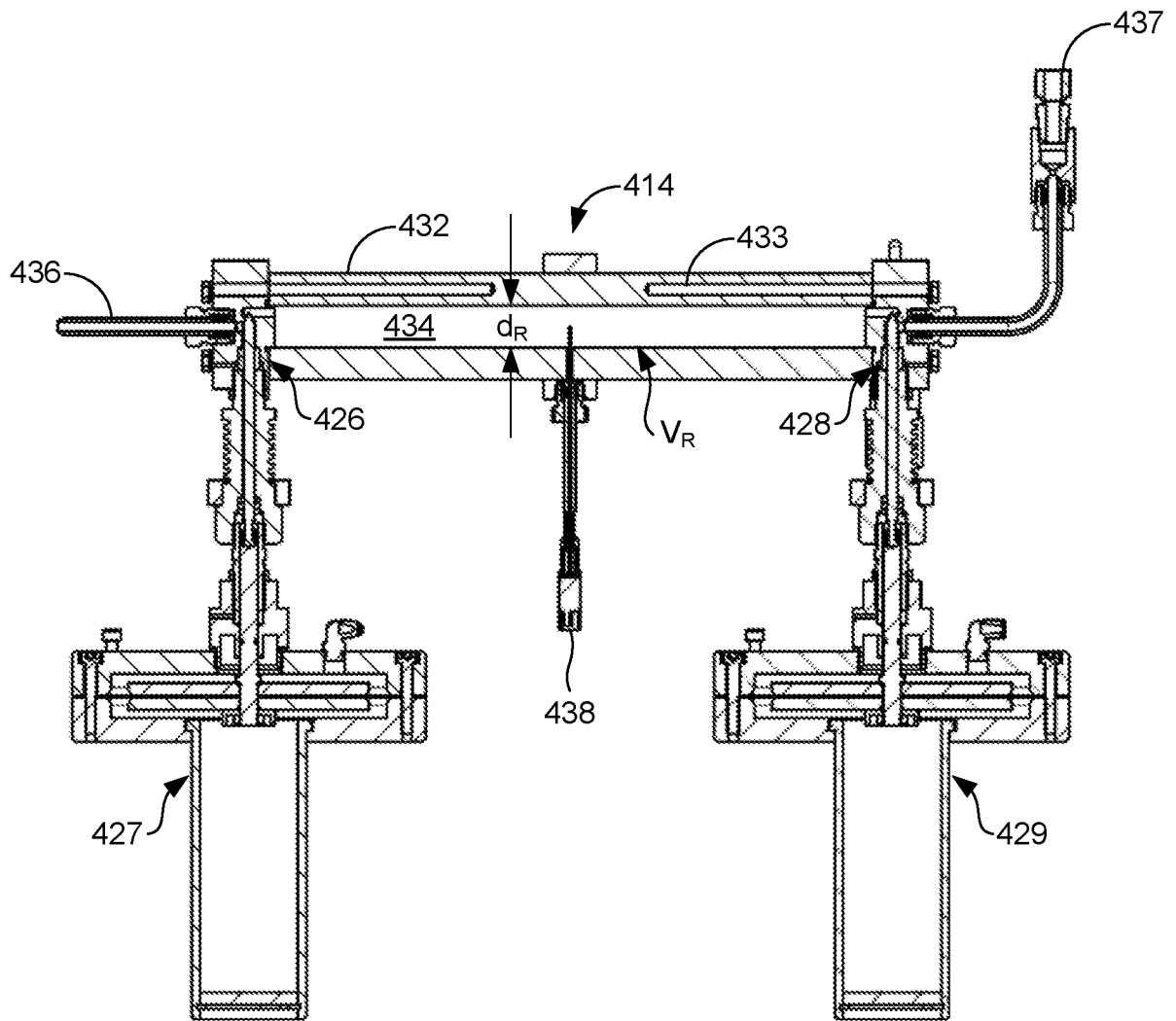


FIG. 18

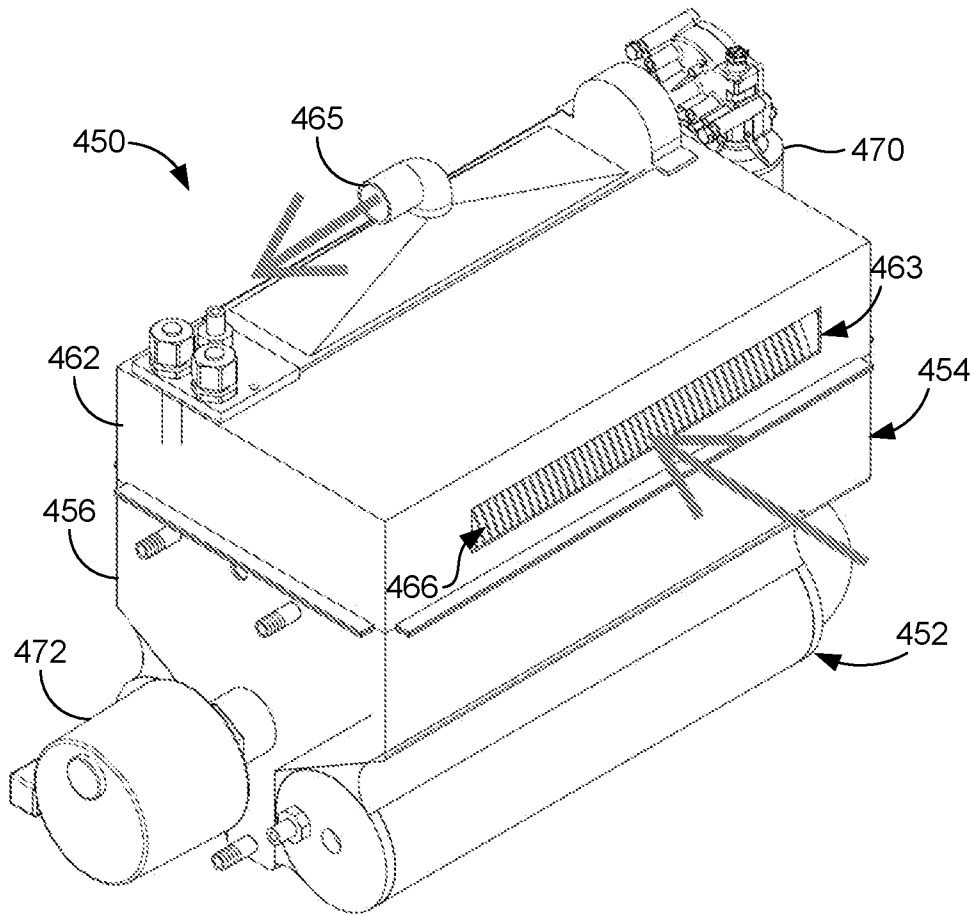


FIG. 19A

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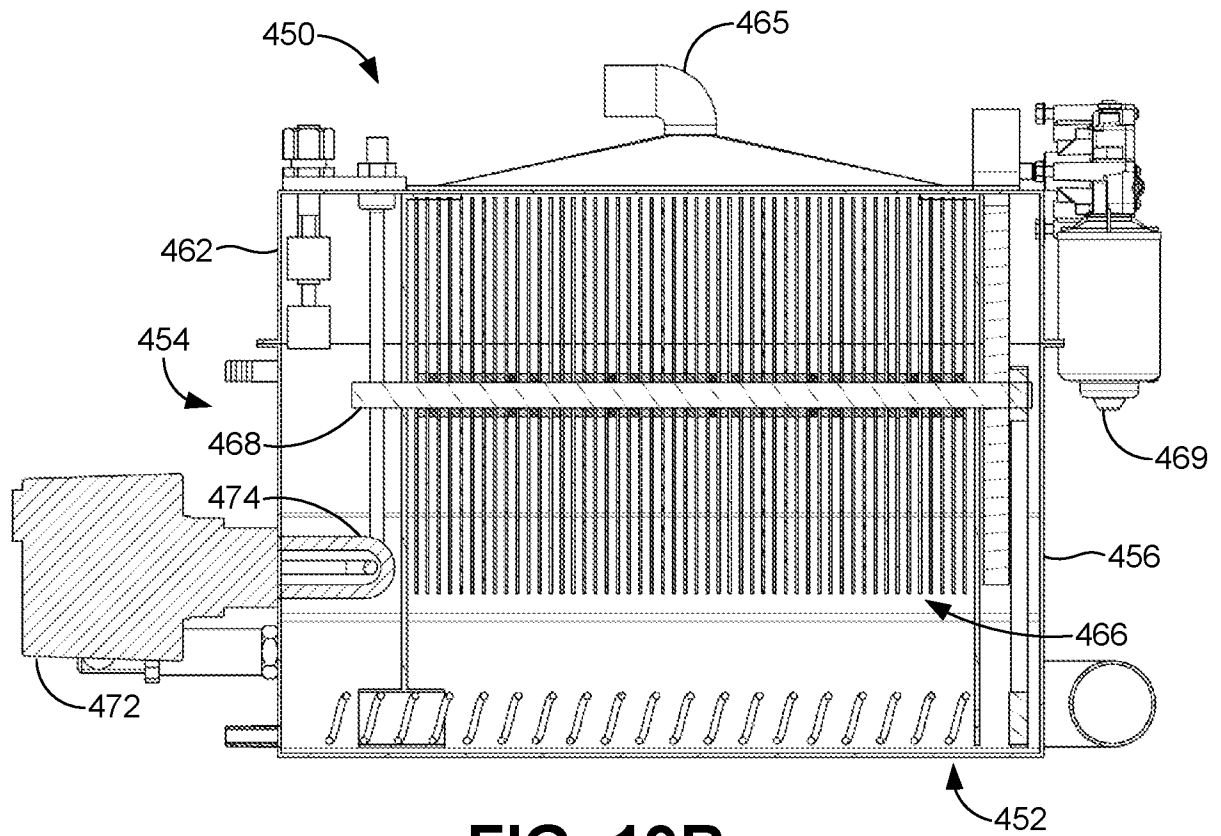


FIG. 19B

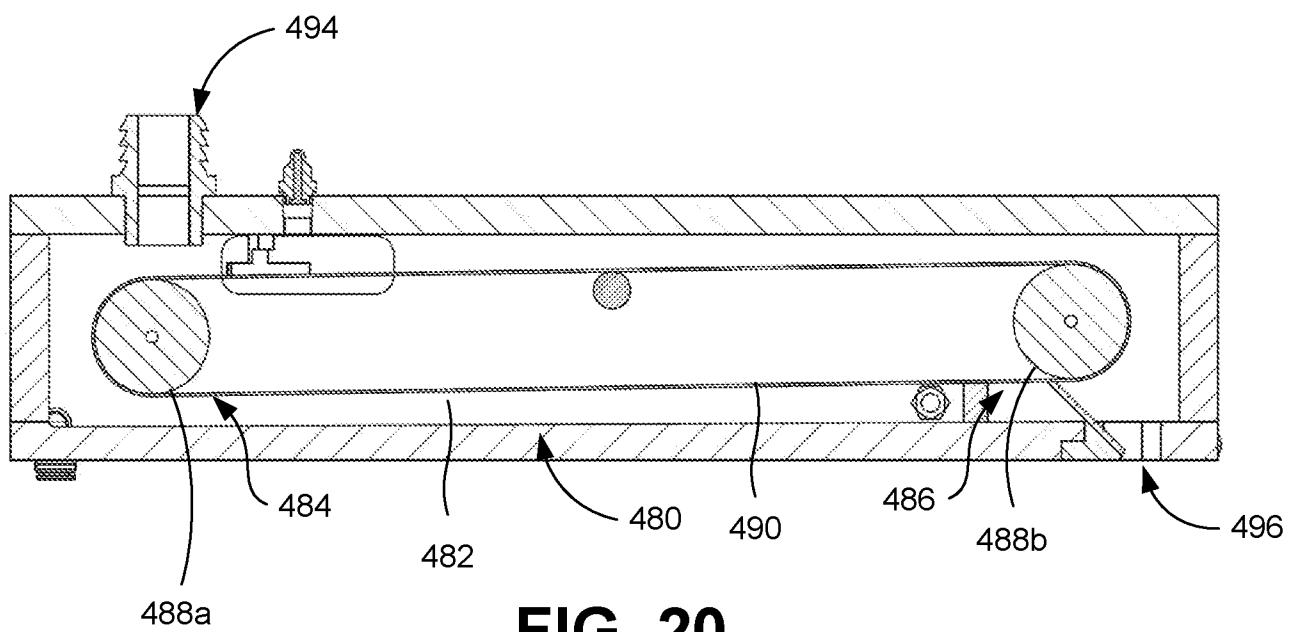


FIG. 20

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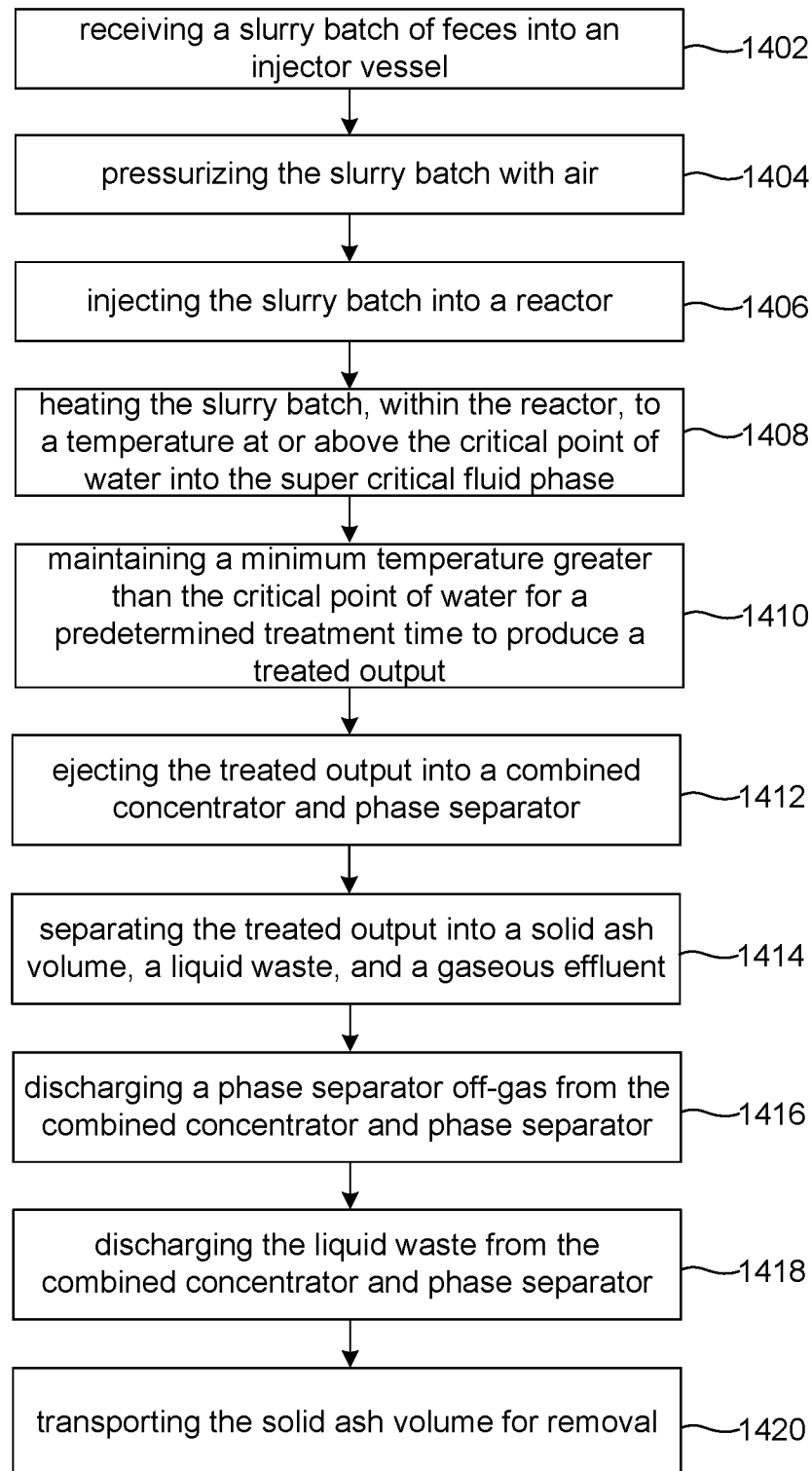


FIG. 21

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/073817

A. CLASSIFICATION OF SUBJECT MATTER					
INV.	C02F9/00	E03D1/14	B01D29/35	B01D29/90	B01D33/04
	B01D61/02	B01D61/14	B01D61/16	B01D61/58	E03D5/014
	E03D11/11	C02F11/08	C02F11/121	C02F11/123	C02F11/128
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)					
E03D C02F B01D E03F A47K					
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)					
EPO-Internal, WPI Data					
C. DOCUMENTS CONSIDERED TO BE RELEVANT					
Category*	Citation of document, with indication, where appropriate, of the relevant passages				Relevant to claim No.
X	CN 106 946 432 A (IDEA MACHINERY CO LTD)				55-66,
	14 July 2017 (2017-07-14)				71-89
A	figure 1				1-54,
	abstract				67-70,
	paragraphs [0014] - [0018]				90-96

X	KR 100 966 309 B1 (KWAG MYONG HOON [KR];				55-66,
	SEO MI SUK [KR]) 28 June 2010 (2010-06-28)				71-89
A	figure 1				1-54,
	paragraphs [0001], [0010] - [0042]				67-70,
					90-96

X	WO 2018/031280 A1 (RTI INT [US])				55-66,
	15 February 2018 (2018-02-15)				71-89
A	figures 1-3				1-54,
	paragraphs [0007] - [0048]				67-70,
					90-96

	-/-				
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.					
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Date of the actual completion of the international search			Date of mailing of the international search report		
1 November 2022			21/11/2022		
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016			Authorized officer Rozanska, Agnieszka		

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/073817

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 3 243 801 A1 (FACHHOCHSCHULE NORDWESTSCHWEIZ INST FÜR BIOMASS AND RESSOURCE EFFICIENT) 15 November 2017 (2017-11-15) the whole document -----	1-96
A	JP 2001 259696 A (GEN ATOMICS INC; KOMATSU MFG CO LTD; KURITA WATER IND LTD) 25 September 2001 (2001-09-25) the whole document -----	1-96
A	US 3 856 672 A (BOSWINKLE G ET AL) 24 December 1974 (1974-12-24) the whole document -----	1-96
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A	WO 2016/075705 A2 (RAJASEKARAN SOWMYA [IN]) 19 May 2016 (2016-05-19) the whole document -----	1-96
A	EP 0 827 768 A1 (PREMARK FEG LLC [US]) 11 March 1998 (1998-03-11) the whole document -----	1-96
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Information on patent family members

International application No

PCT/US2022/073817

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JP 2005205314	A	04-08-2005	NONE