

SYSTEMS AND METHODS FOR THE TREATMENT OF MEMBRANES IN WASTEWATER

MANAGEMENT SYSTEMS

Technical Field

[0001] The present disclosure relates generally to systems and methods for managing wastewater, and more specifically, to systems and methods for wastewater management and filtration membranes management.

Background

[0002] Many industrial operations generate wastewater that is high in, among other things, contaminants, dissolved solids, etc., and will require treatment prior to being released, discharged, and/or recycled for other purposes. Various technologies, including membrane filtration technology, are employed in wastewater treatment. Regarding membrane filtration technology, membranes will periodically require maintenance to ensure membrane efficiency and to prevent membrane fouling, which may affect the filtration process and quality of permeate. Eventually, membranes will require replacement, which is oftentimes a costly exercise.

[0003] Conventional approaches to membrane maintenance include the use of strong or concentrated chemicals in cleaning and biological treatment, which although may improve membrane efficiency and prevent membrane fouling, will also result in inadvertently reducing the lifespan of the membranes and more frequent replacement of membranes.

Brief Summary

[0004] Membranes used in membrane filtration technology enable efficient treatment of wastewater through filtration of unwanted contaminants, dissolved particles, etc. To ensure efficiency and prevent membrane fouling, membranes will require frequent maintenance. Such membrane maintenance includes the use of strong or concentrated chemicals in cleaning and biological treatment, which although may improve membrane efficiency and prevent

membrane fouling, will also result in inadvertently reducing the lifespan of the membranes. Such cleaning chemicals may also be harmful to the environment. Accordingly, it is desirable to provide solution to such problems, including an improved membrane treatment method that is less harmful to the environment, increases the efficiency and lifespan of the membranes, and is cost effective.

[0005] Present example embodiments relate generally to and/or include, among other things, systems, subsystems, processors, devices, logic, methods, and processes for addressing conventional problems, including those described above and in the present disclosure, and more specifically, example embodiments relate to systems, subsystems, processors, devices, methods, and processes for managing wastewater, including but not limited to, removal of contaminants and/or dissolved solids from the wastewater. Example embodiments may also relate to systems, subsystems, processors, devices, methods, and processes for managing filtration membranes, including but not limited to, cleaning the membranes in the treatment system.

[0006] In an exemplary embodiment, a system for managing wastewater is described. The system as described is a wastewater treatment system. The wastewater treatment system includes a wastewater inlet. The wastewater inlet is configured to receive wastewater from one or more wastewater streams. The system also includes a main treatment assembly. The main treatment assembly is configured to perform treatment to the wastewater received, via the wastewater inlet, from the one or more wastewater streams. The main treatment system includes a membrane filtration assembly. The membrane filtration assembly includes a membrane filtration inlet and one or more filtration membranes. The one or more filtration membranes may include, but is not limited to, conventional nanofiltration (NF) membranes, reverse osmosis (RO) membranes, brackish water reverse osmosis (BWRO) membranes, sea water reverse osmosis (SWRO) membranes and/or any other suitable membranes which may

be used. The one or more filtration membranes are configured to receive the input (e.g., wastewater) from the membrane filtration inlet and to treat the input (e.g., wastewater) to arrive at a treated wastewater portion and a rejected wastewater portion. The membrane filtration assembly further includes a membrane filtration outlet. The membrane filtration outlet includes a treated water outlet, a flushing water outlet and a wastewater outlet. The treated water outlet is configured manage the first portion of the treated wastewater portion from the one or more filtration membranes. The flushing water outlet is configured to manage a second portion of the treated wastewater portion from the one or more filtration membranes. Further, the wastewater outlet is configured to manage the rejected wastewater portion from the one or more filtration members. The wastewater management system also includes a flushing assembly. The flushing assembly includes a flushing inlet and a flushing outlet. The flushing assembly also includes a flushing storage assembly. The flushing assembly is configured to receive, via the flushing inlet, the second portion of the treated wastewater portion from the flushing water outlet and to store the received second portion of the treated wastewater portion. When the input from the membrane filtration inlet is the second portion of the treated wastewater portion, the second portion of the treated wastewater portion performs a flushing of the one or more filtration membranes to clean the one or more filtration membranes. The wastewater treatment system further includes an input selector that is provided between a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and a downstream output of the flushing outlet. The input selector may include, but not limited to, a 3-way gate valve, n-way gate valve (where n is an integer), or any other valve, selector, gate, or the like. The input selector is configured to transition between a treatment state and a flushing state. The default state of the input selector is the treatment state.

[0007] The treatment state is a state in which the input selector selectively enables fluid communication from the wastewater inlet to the membrane filtration inlet in such a way as to

enable the one or more filtration membranes to receive the wastewater from the membrane filtration inlet. When the input selector is in the treatment state, the input selector does not enable fluid communication from the flushing outlet of the flushing assembly to the membrane filtration inlet. The flushing state is a state in which the input selector selectively enables fluid communication from the flushing outlet of the flushing assembly to the membrane filtration inlet in such a way as to enable the one or more filtration membranes to receive the second portion of the treated wastewater portion stored in the flushing storage assembly. When the input selector is in the flushing state, the input selector does not enable fluid communication from the wastewater inlet to the membrane filtration inlet. The input selector transitions from the treatment state to the flushing state based on a determination of a trigger condition and the trigger condition is a saturation index of the wastewater that is to be treated by the main treatment assembly. The wastewater treatment system further includes a wastewater controller. The wastewater controller is configured to determine whether the trigger condition has been met and responsive to the trigger condition being met, the wastewater controller is configured to selectively control the input selector to transition from the treatment state to the flushing state. The saturation index of the wastewater is determined at one or more locations including the upstream input of the wastewater inlet, the downstream output of the wastewater inlet, the upstream input of the membrane filtration inlet, and/or the downstream output of the membrane filtration inlet. The saturation index may be determined based on at least one or more of the following including fluoride (F) content of the wastewater to be treated, silicon dioxide (SiO₂) content of the wastewater to be treated, alkalinity of the wastewater to be treated, calcium content of the wastewater to be treated, pressure differential between the wastewater to be treated and the first portion of the treated wastewater portion from the treated water outlet, water permeability of the wastewater to be treated, water permeability of the first portion of the treated wastewater portion from the flushing water outlet, salt permeability of the

wastewater to be treated, salt permeability of the first portion of the treated wastewater portion from the treated water outlet, and/or a salt permeability of the second portion of the treated wastewater portion from the flushing outlet. The input selector is further configured to remain in the flushing state for between 10 seconds to 120 seconds when the input selector transitions from the treatment state to the flushing state. Further, the flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet is between 20% to 100%.

[0008] In another exemplary embodiment, a system for managing wastewater is described. The system as described is a wastewater treatment system. The wastewater treatment system includes a wastewater inlet. The wastewater inlet is configured to receive wastewater from one or more wastewater streams. The system also includes a main treatment assembly. The main treatment assembly is configured to perform treatment to the wastewater received, via the wastewater inlet, from the one or more wastewater streams. The main treatment system includes a membrane filtration assembly. The membrane filtration assembly includes, but is not limited to, a membrane filtration inlet and one or more filtration membranes. The one or more filtration membranes may include a reverse osmosis (RO) membrane and/or any other filtration membrane. The one or more filtration membranes are configured to receive the input (e.g., wastewater) from the membrane filtration inlet. The wastewater management system also includes a flushing assembly. The flushing assembly is configured to receive a portion of the treated wastewater from the one or more filtration membranes and to store the received portion of the treated wastewater. When the membrane filtration inlet receives the portion of the treated wastewater portion from the flushing assembly, the received portion of the treated wastewater portion performs a flushing of the one or more filtration membranes to clean the one or more filtration membranes.

[0009] The wastewater treatment system also includes a main controller. The main controller is configured to transition the main treatment assembly to be in a treatment state and stops fluid

communication from the flushing assembly to the membrane filtration inlet. The main controller is also configured to transition the main treatment assembly to be in a flushing state and stops fluid communication from the wastewater inlet to the membrane filtration inlet. The wastewater treatment system further includes an input selector that is configured to receive commands from the main controller to transition the main treatment assembly between the treatment state and the flushing state. The input selector is provided between a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and a downstream output of the flushing outlet. The input selector may include, but not limited to, a 3-way gate valve, n-way gate valve (where n is an integer), or any other valve, selector, gate, or the like. The default state is the treatment state. The main controller is further configured to transition the main treatment assembly from the treatment state to the flushing state based on a determination of a trigger condition and the trigger condition is a saturation index of the wastewater that is to be treated by the main treatment assembly. The saturation index of the wastewater is determined at one or more locations including the upstream input of the wastewater inlet, the downstream output of the wastewater inlet, the upstream input of the membrane filtration inlet, and/or the downstream output of the membrane filtration inlet. The saturation index may be determined based on at least one or more of the following including fluoride (F) content of the wastewater to be treated, silicon dioxide (SiO₂) content of the wastewater to be treated, alkalinity of the wastewater to be treated, calcium content of the wastewater to be treated, pressure differential between the wastewater to be treated and the first portion of the treated wastewater portion from the treated water outlet, water permeability of the wastewater to be treated, water permeability of the first portion of the treated wastewater portion from the flushing water outlet, salt permeability of the wastewater to be treated, salt permeability of the first portion of the treated wastewater portion from the treated water outlet, and/or a salt permeability of the second portion of the treated wastewater portion from the

flushing outlet. The input selector is further configured to remain in the flushing state for between 10 seconds to 120 seconds when the input selector transitions from the treatment state to the flushing state. Further, the flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet is between 20% to 100%.

[0010] Various terms used herein have special meanings within the present technical field. Whether a particular term should be construed as such a "term of art" depends on the context in which that term is used. Such terms are to be construed in light of the context in which they are used in the present disclosure and as one of ordinary skill in the art would understand those terms in the disclosed context. The above definitions are not exclusive of other meanings that might be imparted to those terms based on the disclosed context.

[0011] Additionally, the section headings and topic headings herein are provided for consistency with the suggestions under various patent regulations and practice, or otherwise to provide organizational cues. These headings shall not limit or characterize the embodiments set out in any claims that may issue from this disclosure. Specifically, a description of a technology in the "Background" is not to be construed as an admission that technology is prior art to any embodiments in this disclosure. Furthermore, any reference in this disclosure to "invention" in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple inventions may be set forth according to the limitations of the claims issuing from this disclosure, and such claims accordingly define the invention(s), and their equivalents, that are protected thereby. In all instances, the scope of such claims shall be considered on their own merits in light of this disclosure but should not be constrained by the headings herein.

Brief Description of the Figures

[0012] For a more complete understanding of the present disclosure, example embodiments, and their advantages, reference is now made to the following description taken in conjunction with the accompanying figures, in which like reference numbers indicate like features, and:

[0013] Figure 1 illustrates an example embodiment of a system for managing wastewater and filtration membranes;

[0014] Figure 2 illustrates an example embodiment of a main treatment system for managing wastewater;

[0015] Figure 3 illustrates an example embodiment of a flushing assembly for managing wastewater and filtration membranes; and

[0016] Figure 4 illustrates an example embodiment of a method for managing wastewater and filtration membranes.

[0017] Although similar reference numbers may be used to refer to similar elements in the figures for convenience, it can be appreciated that each of the various example embodiments may be considered distinct variations. Example embodiments will now be described with reference to the accompanying figures, which form a part of the present disclosure and which illustrate example embodiments which may be practiced. As used in the present disclosure and the appended claims, the terms "embodiment", "example embodiment", "exemplary embodiment", and "present embodiment" do not necessarily refer to a single embodiment, although they may, and various example embodiments may be readily combined and/or interchanged without departing from the scope or spirit of example embodiments. The terminology as used in the present disclosure and the appended claims is for the purpose of describing example embodiments only and is not intended to be limitations. In this respect, as used in the present disclosure and the appended claims, the term "in" may include "in" and "on", and the terms "a", "an", and "the" may include singular and plural references. Furthermore, as used in the present disclosure and the appended claims, the term "by" may also

mean "from," depending on the context. Furthermore, as used in the present disclosure and the appended claims, the term "if" may also mean "when" or "upon", depending on the context. Furthermore, as used in the present disclosure and the appended claims, the words "and/or" may refer to and encompass any and all possible combinations of one or more of the associated listed items.

Detailed Description

[0018] Present example embodiments relate generally to and/or include systems, subsystems, processors, devices, methods, and processes for addressing conventional problems, including those described above and in the present disclosure, and more specifically, example embodiments relate to systems, subsystems, processors, devices, methods, and processes for managing wastewater and filtration membranes.

[0019] Example embodiments will now be described below with reference to the accompanying figures, which form a part of the present disclosure.

[0020] Example embodiments of a system for managing wastewater and filtration membranes (e.g., wastewater treatment system 100).

[0021] FIGURE 1 illustrates an example embodiment of a wastewater treatment system (e.g., wastewater treatment system 100) for managing wastewater and filtration membranes. The wastewater may be wastewater containing high concentrations of contaminants, dissolved solids, pollutants, etc., or the like. As described in the present disclosure, the wastewater treatment system 100 is configurable or configured to perform such management by performing one or more of a variety functions, actions, and/or processes using one or more of the elements described in the present disclosure.

[0022] In an example embodiment, the wastewater treatment system 100 is configurable or configured to manage wastewater. The wastewater may contain high concentrations of, for example, fluoride, chloride, one or more other organic compounds, elements, etc. The

wastewater treatment system 100 may include a wastewater inlet 110, or the like. the wastewater inlet 110 may be configurable or configured to receive, provide, store or the like, the wastewater to be treated. The wastewater inlet 110 may be configured or configurable to provide the wastewater to be treated to one or more other elements of the system 100, including a main treatment system 200. In another exemplary embodiment, the wastewater inlet 110 may also be configurable or configured to communicate with an input selector 400, which will be described further in the present disclosure, to determine a saturation index (e.g., saturation index of the incoming wastewater to be treated). Such saturation index may be determined based on one or more parameters of the wastewater and/or treated wastewater that is treated by the one or more elements of the wastewater treatment system 100.

[0023] The wastewater treatment system 100 includes a main treatment system 200. The main treatment system 200 is configurable or configured to perform a variety of functions, including treatment of the wastewater. The main treatment system 200 may include one or more membrane filtration assemblies. The one or more membrane filtration assemblies may be or include an automatic backwash filter system, an ultrafiltration system, a cartridge filtration system, a multimedia filtration, a membrane cartridge filtration, and/or any other suitable membrane filtration systems which may be used. The main filtration assembly may include a membrane filtration inlet 210, or the like, configurable or configured to receive the wastewater to be treated, as provided by the wastewater inlet 110. The membrane filtration inlet 210 may also be configurable or configured to communicate with an input selector 400, which will be described further in the present disclosure, to determine a saturation index (e.g., saturation index of the incoming wastewater to be treated). Such saturation index may be based on one or more parameters of the wastewater and/or treated wastewater that is treated by the one or more elements of the wastewater treatment system 100. The one or more membrane filtration assemblies may also include one or more filtration membranes 220. The one or more filtration

membranes 220 may be configured or configurable to remove impurities, pollutants, contaminants, or the like, such as suspended or dissolved solids, particles, organic materials, sediments, etc. from the wastewater so as to arrive at a treated wastewater and a rejected wastewater (e.g., 2 separate streams or outputs). The one or more membrane filtration assemblies further include a membrane filtration outlet assembly 230. The membrane filtration outlet assembly 230 may be configurable or configured to receive the treated wastewater and the rejected wastewater from the one or more filtration membranes 220. The membrane filtration outlet assembly 230 may further include a treated water outlet 232 that is configurable or configured to manage a portion of the treated wastewater (e.g., a first portion of the treated wastewater from among all of the treated wastewater being outputted from the one or more membrane filtration membranes 220). The membrane filtration outlet assembly 230 may also include a flushing water outlet 234 that is configurable or configured to manage a portion of the treated wastewater (e.g., a second portion of the treated wastewater from among all of the treated wastewater being outputted from the one or more membrane filtration membranes 220, which is different from the first portion of the treated wastewater). The membrane filtration outlet assembly 230 may also include a wastewater outlet 236 that is configurable or configured to manage the rejected wastewater (e.g., which includes the impurities, pollutants, contaminants, or the like, such as suspended or dissolved solids, particles, organic materials, sediments, etc., removed from the wastewater).

[0024] The wastewater treatment system 100 further includes a flushing assembly 300. The flushing assembly system 300 may be configurable or configured to perform a variety of functions, including storing and/or providing treated wastewater for membrane flushing process. The flushing assembly 300 includes a flushing inlet 310 that is configurable or configured to receive a portion of the treated wastewater (e.g., second portion of the treated wastewater) from the flushing water outlet 234. The flushing assembly 300 also includes a

flushing storage 320 that is configurable or configured to receive and to store the portion of the treated wastewater (e.g., second portion of the treated wastewater). In an example, the flushing storage 320 may store the portion of the treated wastewater (e.g., second portion of the treated wastewater) which may be provided to the main treatment system 200 during a membrane flushing process. The flushing assembly 300 may also include a flushing outlet 330 that is configurable or configured to provide the received portion of the treated wastewater (e.g., second portion of the treated wastewater) to the main treatment system 200 when the main treatment system 200 transitions into a flushing state or when a determined saturation index based on one or more parameters of the wastewater and/or treated wastewater that is treated by one or more elements of the wastewater treatment system 100 meets the trigger condition.

[0025] The wastewater treatment system 100 includes an input selector 400. The input selector 400 is configurable or configured to perform a variety of functions, including transitioning between a treatment state and a flushing state. In another exemplary embodiment, the input selector 400 is also configurable or configured to receive one or more commands from a main controller 500, which will be described further in the present disclosure, when transitioning between a treatment state and a flushing state. The input selector 400 is provided between a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and a downstream output of the flushing outlet. The input selector 400 may be, but not limited to 3-way gate valve, n-way gate valve (where n is an integer), or any other valve, selector, gate, or the like.

[0026] During a treatment state, which is the default state of the input selector 400, the input selector 400 selectively enables the wastewater inlet 110 to provide wastewater into the one or more filtration membranes 220 via the membrane filtration inlet 210. The input selector 400 selectively disables the flushing assembly 300 to provide the portion of the treated wastewater (e.g., second portion of the treated wastewater) into the one or more filtration membranes 220

via the membrane filtration inlet 210. When a flushing state is triggered, the input selector 400 selectively enables the flushing outlet 330 to provide the portion of the treated wastewater (e.g., second portion of the treated wastewater) into the one or more filtration membranes 220 via the membrane filtration inlet 210. The input selector 400 selectively disables the wastewater inlet 110 to provide wastewater into the one or more filtration membranes 220 via the membrane filtration inlet 210.

[0027] In an exemplary embodiment, the input selector 400 transitions the main treatment assembly 200 from a treatment state to a flushing state based on a determination of a trigger condition. The trigger condition may be or include one or more saturation indexes determined based on one or more parameters of the wastewater and/or treated wastewater that is treated by one or more elements of the wastewater treatment system 100. The saturation index may be determined at one or more locations or portions of the wastewater treatment system 100, including an upstream input of the wastewater inlet, a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and/or a downstream output of the membrane filtration inlet. When the input selector 400 transitions the main treatment assembly 200 to a flushing state, the main treatment assembly 200 may remain in the flushing state for a period of time (e.g., between 10 seconds to 120 seconds, or more or less) when the input selector transitions from the treatment state to the flushing state. Further, the flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet may be between 20% to 100%.

[0028] The wastewater treatment system may also include a main controller 500. The main controller 500 is configurable or configured to perform a variety of functions, including transitioning between a treatment state and a flushing state. Alternatively and/or in addition, the main controller 500 is also configurable or configured to provide one or more commands to the input selector 400 to transition between a treatment state and a flushing state. In an

exemplary embodiment, the main controller 500 may be a wastewater controller. During a treatment state, the main controller 500 stops all fluid communication from the flushing assembly 300 to the membrane filtration inlet 210. At the same time, the membrane filtration inlet 210 is configurable or configured to receive one or more fluid communication from the wastewater inlet 110. When a flushing state is triggered, the main controller 500 stops all fluid communication from the wastewater inlet 110 to the membrane filtration inlet 210. At the same time, the membrane filtration inlet 210 is configurable or configured to receive one or more fluid communication from the flushing assembly 300. In another exemplary embodiment, the main controller 500 transitions the main treatment assembly 200 from a treatment state to a flushing state based on a determination of a trigger condition. The default system for the water treatment system is a treatment system. The trigger condition may be one or more determined saturation index based on one or more parameters of the wastewater and/or treated wastewater that is treated by one or more elements of the wastewater treatment system 100. The saturation index are determined at one or more locations including an upstream input of the wastewater inlet, a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet and/or a downstream output of the membrane filtration inlet. Upon determining the one or more saturation index and determining that the trigger condition is met, the main controller 500 may provide one or more commands to the input selector 400 to transition the main treatment assembly 200 between the treatment state and the flushing state. When the main controller 500 transitions the main treatment assembly 200 to a flushing state, the main treatment assembly 200 may remain in the flushing state for a period of time (e.g., between 10 seconds to 120 seconds, or more or less) when the input selector transitions from the treatment state to the flushing state. Further, the flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet may be between 20% to 100%.

[0029] These and other elements of the system 100 will now be further described with reference to the accompanying figures.

[0030] The wastewater inlet (e.g., wastewater inlet 110)

[0031] As illustrated in at least **FIGURE 1**, the water treatment system 100 for managing wastewater includes one or more wastewater inlet (e.g., wastewater inlet 110). The wastewater inlet 110 configurable or configured to manage the input and/or output of wastewater in the water treatment system 100 and other functions, operations, actions, methods, and/or processes described in the present disclosure.

[0032] As a non-limiting example, the wastewater inlet 110 is configured or configurable to receive, provide, store, or the like, wastewater from one or more sources. For example, the wastewater inlet 110 may receive the wastewater from waterways, pipes, or the like, that connects from an area, catchment area, pond, and/or industrial wastewater generated from, but not limited to, semiconductor industry, and any other industries that may generate similar industrial wastewater.

[0033] The wastewater inlet 110 may also be and/or include a collection area, tank, storage or the like. In such an example, the wastewater to be treated may be collected, fed and/or stored prior to feeding the wastewater into the wastewater treatment system 100. In another exemplary embodiment, the wastewater inlet 110 may also receive wastewater from one or more streams of rejected wastewater from one or more wastewater treatment processes and/or systems. The one or more wastewater streams or any other sources may include, but not limited to, wastewater stream with high concentration of copper, wastewater stream with high concentration of silica, wastewater stream with high concentration of copper, etc. The wastewater is provided through the wastewater inlet 110 at highly variable flows and concentrations into the main treatment system 200. Further, the wastewater inlet 110 is also

configurable or configured to communicate with an input selector 400, which will be described further in the present disclosure.

[0034] The main treatment system (e.g., main treatment system 200)

[0035] As illustrated in at least **Figure 1**, the water treatment system 100 for managing wastewater includes one or more main treatment system (e.g., main treatment system 200). The main treatment system 200 is configurable or configured to treat the wastewater in the water treatment system 100, communicating with a flushing assembly 300 to receive and provide one or more input/output, communicating with an input selector 400 and/or a main controller 500 to trigger a transition between a treatment state and a flushing state in the main treatment system 200, and other functions, operations, actions, methods, and/or processes described in the present disclosure.

[0036] As illustrated in at least **FIGURE 2**, the main treatment system 200 may include one or more membrane filtration assembly. The one or more membrane filtration assembly may be, but is not limited to, an automatic backwash filter system, an ultrafiltration system, a cartridge filtration system, a multimedia filtration, a membrane cartridge filtration, and any other suitable membrane filtration assemblies/systems which may be used. The membrane filtration assembly includes one or more membrane filtration inlet 210, one or more filtration membranes 220, and one or more membrane filtration outlet assembly 230. The main filtration assembly may include a membrane filtration inlet 210, or the like, configurable or configured to receive the wastewater to be treated provided by the wastewater inlet 110.

[0037] The one or more membrane filtration assembly may also include one or more filtration membranes 220. Each filtration membrane 220 may be configured or configurable to remove impurities, pollutants and/or contaminants such as suspended or dissolved solids, particles, organic materials, sediments, etc. from the wastewater. Each filtration membrane 220 may be or include, but not limited to, conventional nanofiltration (NF) membranes, reverse osmosis

(RO) membranes, brackish water reverse osmosis (BWRO) membranes, sea water reverse osmosis (SWRO) membranes and/or any other suitable membranes which may be used. The wastewater is passed through the filtration membranes 220 to arrive at one or more output streams including a treated wastewater and a rejected wastewater. The treated wastewater from the filtration membranes 220 is an output which is substantially free of contaminants or pollutants.

[0038] The one or more membrane filtration assembly also includes one or more membrane filtration outlet assemblies 230. The membrane filtration outlet assembly 230 is configurable or configured to receive the treated wastewater and the rejected wastewater from the one or more filtration membranes 220 after the filtration process. The membrane filtration outlet assembly 230 further includes a treated water outlet 232, a flushing water outlet 234, and a wastewater outlet 236.

[0039] The treated water outlet 232 is configurable or configured to receive and manage a portion of the treated wastewater (e.g., a first portion of the treated wastewater). A portion of the treated wastewater from the filtration membranes 220 is directed to the treated water outlet 232 and is being directed to other processes and/or systems for storage, treatment, recirculation or disposal. For example, the portion of the treated wastewater may be further treated to arrive at clean or pure water products which can be safely disposed into a water source in the environment, reused in the treatment system where applicable and/or used in any other suitable applications.

[0040] The flushing water outlet 234 is configurable or configured to receive and manage a portion of the treated wastewater (e.g., a second portion of the treated wastewater). A portion of the treated wastewater from the filtration membranes 220, that is separate from the portion of treated wastewater received by the treated water outlet 232, is directed to the flushing water outlet 234 and is being directed to a flushing assembly 300 for storage. The portion of treated

wastewater that is stored will be used during a membrane flushing process in the main treatment assembly 200.

[0041] The wastewater outlet 236 is configurable or configured to receive and manage the rejected wastewater. The rejected wastewater from the filtration membranes 220 is directed to the wastewater outlet 236 and is being directed to other processes and/or systems for treatment or disposal. For example, the rejected wastewater may still contain contaminants or pollutants and may be directed via the wastewater outlet to another treatment process or system to further remove them before storage, treatment, recirculation or disposal. Alternatively, and/or in addition, the rejected wastewater may be discharged into the environment without further treatment as there are significantly lower or safe level of contaminants and/or pollutants in the rejected wastewater.

[0042] The flushing assembly (e.g., flushing assembly 300)

[0043] As illustrated in at least **Figure 1**, the water treatment system 100 for managing wastewater may include one or more flushing assemblies (e.g., flushing assembly 300). The flushing assembly 300 is configurable or configured to manage the input and/or output of a treated wastewater, communicating the main treatment system 200 to receive and provide one or more input/output, communicating with an input selector 400 and/or a main controller 500 to trigger a transition between a treatment state and a flushing state in the main treatment system 200, and other functions, operations, actions, methods, and/or processes described in the present disclosure.

[0044] As illustrated in at least **FIGURE 3**, the main treatment system 200 may include one or more flushing assembly 300. The flushing assembly 300 is configured or configurable to receive, provide, store, or the like, a portion of the treated wastewater from the main treatment system 200. The flushing assembly 300 includes a flushing inlet 310 that is configurable or configured to receive a portion of the treated wastewater (e.g., second portion of the treated

wastewater) from wastewater from the main treatment system 200 via the flushing water outlet 234.

[0045] The flushing assembly 300 may also include a flushing storage 320 that is configurable or configured to receive and to store the portion of the treated wastewater (e.g., second portion of the treated wastewater) received from the main treatment system 200. The stored portion of the treated wastewater is used for a membrane flushing process of the filtration membranes 220 in the main treatment system 200. Alternatively and/or in addition, the flushing storage 320 may also receive and store from one or more treated wastewater or any other water sources from one or more external sources which may be provided to the main treatment system 200 for membrane flushing process.

[0046] The flushing assembly 300 may also include a flushing outlet 330 that is configurable or configured to provide the stored portion of the treated wastewater (e.g., second portion of the treated wastewater) to the main treatment system 200. The portion of the treated wastewater (e.g., second portion of the treated wastewater) is directed to the main treatment system 200 when the input selector 400 and/or the main controller 500 triggers a transition from a treatment state to a flushing state. The transition from a treatment state to a flushing state by an input selector 400 may be triggered by one or more saturation index determined by a main controller 500. The determination of the saturation index by the main controller 500 will be further described in the present disclosure.

[0047] The input selector (e.g., input selector 400)

[0048] As illustrated in at least **Figure 1**, the water treatment system 100 for managing wastewater may include one or more input selectors (e.g., input selector 400). The input selector 400 is configurable or configured to transition from a treatment state and a flushing state in the water treatment system 100, and other functions, operations, actions, methods, and/or processes described in the present disclosure. Further, the input selector 400 may also

be configurable or configured to communicate with the wastewater inlet 110, communicate with the main treatment system 200 and communicate with the flushing assembly 300. Alternatively and/or in addition, the input selector 400 may also communicate with the main controller 500.

[0049] In an exemplary embodiment, the input selector 400 is configurable or configured to transition from a treatment state to a flushing state and vice versa. The input selector 400 in the wastewater treatment system 100 is provided between a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and a downstream output of the flushing outlet. The input selector 400 is configurable or configured to receive at least one or more commands from the main controller 500 which determines whether a trigger condition is met for the input selector 400 to transition from a treatment state to a flushing state. The default state for the input selector 400 is the treatment state. Further, the input selector 400 may also include, but not limited to, a 3-way gate valve, n-way gate valve (where n is an integer), or any other valve, selector, gate, or the like.

[0050] In another exemplary embodiment, the input selector 400 may be configured to enable and/or cooperate to enable communication from or between the wastewater inlet 110 and the membrane filtration inlet 210 when in a treatment state. When in a treatment state, the input selector 400 communicates with the wastewater inlet 110 to provide or direct the wastewater to the membrane filtration inlet 210 of the main treatment system 200. At the same time, the input selector 400 is also in communication with the flushing outlet 330 of the flushing assembly 300 to not provide or direct the portion of treated wastewater (e.g., second portion of treated wastewater) in the flushing storage 320 to the membrane filtration inlet 210. The wastewater as received by the membrane filtration inlet 210 is provided to the one or more filtration membranes 220 to undergo the filtration process. The filtration process by the one or more filtration membranes 220 and its subsequent steps of treating and managing wastewater

by the one or more elements of the wastewater treatment system 100 are as described above in the present disclosure.

[0051] In another exemplary embodiment, the input selector 400 may be configured to enable and/or cooperate to enable communication from or between the flushing outlet 330 of the flushing assembly 300 and the membrane filtration inlet 210 of the main treatment system 200 when in a flushing state. When in a flushing state, the input selector 400 communicates with the flushing outlet 330 to provide or direct the portion of treated wastewater (e.g., second portion of treated wastewater) from the flushing storage 320 to the membrane filtration inlet 210. At the same time, the input selector 400 is also in communication with the wastewater inlet 110 to not provide or direct the wastewater to the membrane filtration inlet 210 of the main treatment system 200. The portion of treated wastewater as received by the membrane filtration inlet 210 is provided to the one or more filtration membranes 220 to undergo the membrane flushing process. The membrane flushing process of the one or more filtration membranes 220 allows the treated wastewater to force through the filtration membranes 220 causing the pores of the membranes to be cleaned or flushed of any particles or contaminants that are present. The membrane flushing process may also remove constructed layer of contaminants from wastewater treatment. Depending on various factors and purpose of the filtration membrane cleaning process, the membrane flushing process may be, but not limited to, forward flush, backward flush, etc. and/or a combination thereof. The input selector 400 may be configurable or configured to remain in the flushing state for a period of time (e.g., between 10 seconds to 120 seconds, or more or less) when the input selector 400 transitions from the treatment state to the flushing state. Further, the flow rate of the portion of treated wastewater from the flushing assembly 300 into the membrane filtration inlet 310 to clean the filtration membranes 320 may be controlled or maintained to be between 20% to 100%.

[0052] The input selector 400 may be configurable or configured to be in the default state, which is the treatment state after a stipulated time (e.g., 120 seconds, 10 minutes, 30 minutes, 1 hour, 3 hours, etc.). Alternatively and/or in addition, the input selector 400 may also be configurable or configured to be or revert to the default treatment state when the saturation index is determined again after the flushing state is initiated (and/or after a period of time thereafter) and the saturation index no longer falls within the threshold or range of a trigger condition. The saturation index may be measured or determined in real-time, periodically, intermittently, continuously, and/or at one or more stipulated timings during, before, and/or after the flushing state.

[0053] The main controller (e.g., main controller 500)

[0054] As illustrated in at least **Figure 1**, the water treatment system 100 for managing wastewater includes one or more main controllers (e.g., main controller 500). The main controller 500 is configurable or configured to provide one or more commands to an input selector 400 to transition from a treatment state and a flushing state in the water treatment system 100, and other functions, operations, actions, methods, and/or processes described in the present disclosure. Further, the main controller 500 may also be configurable or configured to communicate with the wastewater inlet 110, to communicate with the main treatment system 200, to communicate with the flushing assembly 300 and to communicate with the input selector 400.

[0055] In an exemplary embodiment, the main controller 500 is configurable or configured to determine if a trigger condition has been met before the input selector 400 transitions from its default state (e.g., treatment state) to a flushing state. The trigger condition may be or include a measure of a saturation index of the wastewater that is to be treated by the main treatment assembly 200. Alternatively and/or in addition, the saturation index of the treated wastewater may also be determined for a trigger condition. A saturation index in the present disclosure

may be or include a measure to be used to determine whether the wastewater or the treated water is saturated, under-saturated or oversaturated with respect to one or more elements such as pollutants, contaminants, minerals, or the like. The saturation index may be based on one or more values of measured parameters of the wastewater and/or treated wastewater. For example, a high saturation index may indicate that there is a possibility that membrane fouling, scaling, and/or corrosion has occurred or formed in the treatment system particularly in the filtration membranes (or may rapidly or more quickly occur or form). A reduction in permeate flux and/or inefficient removal of contaminants or pollutants from the wastewater are some examples that may be seen when a saturation index is high.

[0056] For example, the main controller 500 may receive measurements of parameters such as, but not limited to, a fluoride (F) content in the wastewater to be treated, a silicon dioxide (SiO₂) content in the wastewater to be treated, a calcium (Ca) content in the wastewater to be treated, and/or the alkalinity of the wastewater that is to be treated when determining the saturation index. The main controller 500 may also be configured to receive an alkalinity of the wastewater to be treated, a water permeability of the wastewater to be treated, and a salt permeability of the wastewater to be treated when determining the saturation index. Further, a water permeability of the treated wastewater, a water permeability of the portion of the treated wastewater that is received by the flushing assembly 300, a salt permeability of the treated wastewater, and a salt permeability of the portion of the treated wastewater that is received by the flushing assembly may also be measured to determine the saturation index.

[0057] The saturation index is measured at one or more locations in the wastewater treatment system 100 including an upstream input of the wastewater inlet 110, a downstream output of the wastewater inlet 110, an upstream input of the membrane filtration inlet 210, and/or a downstream output of the membrane filtration inlet 210. Various values of the parameters may also be measured at similar locations. Alternatively and/or in addition, the values may also be

measured at different or separate locations in the wastewater treatment system 100 and are subsequently directed to the main controller 500.

[0058] The saturation index at the various locations may be determined through various methods or processes. One or more sensors and/or analyzers may be present and configured to measure the values of the parameters as disclosed above. The one or more sensors and/or analyzers are configurable or configured to measure the values of the parameters including the pH, fluoride concentration or content, calcium concentration or content, water permeability, etc. of the wastewater to be treated and the treated wastewater in the wastewater treatment system 100. Examples of sensors and/or analyzers that may be used to monitor and measure the values are, but not limited to, pH sensors, total suspended solids sensors, substance detection sections, ion selective sensors, etc. These sensors and/or analyzers send the measured values to the main controller 500 for further processing and determination on whether the saturation index that is based on these measured parameter values meets the trigger condition. For example, the main controller 500 may receive one or more values of the parameters as measured at the one or more disclosed locations. With the values obtained, the main controller 500 may compare these values with historical or predetermined values of the one or more parameters to arrive at a determination on whether the saturation index meets the trigger condition. Alternatively, the saturation index may be calculated and determined using formulas or algorithms using one or more measured parameter values. Alternatively, the saturation index may also be calculated and determined through external sources using the measured parameter values. The determined saturation index is then provided or input in the system for further processing. Once a saturation index is determined, the main controller 500 is configurable or configured to determine if the saturation index is within the threshold or range of a trigger condition (e.g., transition to a flushing state).

[0059] When it is determined that the saturation index falls within the threshold or range of a trigger condition, the trigger condition is met and the main controller 500 is configured to transition the main treatment assembly 200 from the treatment state to a flushing state. The main controller 500 may also provide at least one command to the input selector 400 to transition from the treatment state to a flushing state. For example, a high saturation index typically indicates that there is a possibility that membrane fouling, scaling, and/or corrosion has occurred or formed in the treatment system particularly in the filtration membranes. A reduction in permeate flux and/or inefficient removal of contaminants or pollutants from the wastewater are some examples that may be seen when a saturation index is high. As such, a membrane flushing process (e.g., transitioning to a flushing state) may be required.

[0060] In an example, the main controller 500 may be configured to enable and/or cooperate to enable communication from or between the flushing outlet 330 of the flushing assembly 300 and the membrane filtration inlet 210 of the main treatment system 200 when in a flushing state. When in a flushing state, the main controller 500 communicates with the flushing outlet 330 to provide or direct the portion of treated wastewater (e.g., second portion of treated wastewater) from the flushing storage 320 to the membrane filtration inlet 210. At the same time, the main controller 500 is also in communication with the wastewater inlet 110 to not provide or direct the wastewater to the membrane filtration inlet 210 of the main treatment system 200. The portion of treated wastewater as received by the membrane filtration inlet 210 is provided to the one or more filtration membranes 220 to undergo the membrane flushing process. The membrane flushing process of the one or more filtration membranes 220 allows the treated wastewater to force through the filtration membranes 220 causing the pores of the membranes to be cleaned or flushed of any particles or contaminants that are present. The membrane flushing process also removes constructed layer of contaminants from wastewater treatment. The membrane flushing process may be, but not limited to, forward flush, backward

flush, etc. and/or a combination thereof. The main controller 500 is further configured to transition the main treatment assembly 200 to remain in the flushing state for a period of time (e.g., between 10 seconds to 120 seconds, or more or less) when in the flushing state. Further, the flow rate of the portion of treated wastewater from the flushing assembly 300 into the membrane filtration inlet 310 to clean the filtration membranes 320 may be controlled or maintained to be between 20% to 100%.

[0061] The main controller 500 may also transition the main treatment assembly 200 to revert to the default state which is the treatment state after a stipulated time (e.g., 120 seconds, 5 minutes, 15 minutes, 30 minutes, 1 hour, 3 hours, etc.) or longer. Alternatively and/or in addition, the main controller may also provide at least one command to the input selector 400 to revert to the default state which is the treatment state. Alternatively and/or in addition, the main treatment system 200 and/or the input selector 400 may also be configurable or configured to revert to the default treatment state, via the main controller 500, when the saturation index is determined again after the flushing state is initiated and the saturation index no longer falls within the threshold or range of a trigger condition. The saturation index may be measured or determined in real-time or at one or more stipulated timings during the flushing state.

[0062] In another example, the main controller 500 is configured to enable and/or cooperate to enable communication from or between the wastewater inlet 110 and the membrane filtration inlet 210 when in a treatment state. When it is determined that the saturation index is not or no longer falls within the threshold or range of a trigger condition, the main controller 500 is configured to transition the main treatment assembly 200 from the flushing state to a treatment state. The main controller 500 may also provide at least one command to the input selector 400 to transition from the flushing state to a treatment state. When in a treatment state, the main controller 500 communicates with the wastewater inlet 110 to provide or direct the

wastewater to the membrane filtration inlet 210 of the main treatment system 200. At the same time, the main controller 500 is also in communication with the flushing outlet 330 of the flushing assembly 300 to not provide or direct the portion of treated wastewater (e.g., second portion of treated wastewater) in the flushing storage 320 to the membrane filtration inlet 210. The wastewater as received by the membrane filtration inlet 210 is provided to the one or more filtration membranes 220 to undergo the filtration process. The filtration process by the one or more filtration membranes 220 and its subsequent steps of treating and managing wastewater by the one or more elements of the wastewater treatment system 100 are as described above in the present disclosure.

[0063] In an exemplary embodiment, the main controller 500 may also be a wastewater controller (e.g., wastewater controller 500). Similarly, the wastewater controller 500 functions to transition between a treatment state and a flushing state in the input selector 400.

[0064] The wastewater treatment system 100 may also include a heat exchanger (not shown). Brine, usually sodium chloride or calcium chloride is typically accumulated in high concentrations after treating wastewater. Treated wastewater may be recycled into the wastewater treatment system for various uses and/or applications. This may cause deterioration in any treatment system especially if the recycled wastewater is high in brine concentrations. As such, additional treatment is required before passing the brine containing wastewater through the filtration membranes for brine concentration or to desalt brine waters.

[0065] Example embodiments of a method for managing wastewater and filtration membranes (e.g., method 600).

[0066] **Figure 4** illustrates an example embodiment of a method (e.g., method 600) for managing wastewater and filtration membranes. The method 600 is directed to managing wastewater containing high concentrations of contaminants, dissolved solids, pollutants, or the like, managing the filtration membranes through membrane flushing process, and other

functions, operations, actions, methods, and/or processes described in the present disclosure. The method 600 includes receiving wastewater 610, treating the wastewater 620, storing the treated wastewater 630, determining saturation index 640 and flushing filtration membranes 650. The one or more actions of method 600 may be performed by one or more elements in the wastewater treatment system 100 as described in the present disclosure.

[0067] In an exemplary embodiment, the method 600 provides for management of wastewater and filtration membranes in a wastewater treatment system 100. The method 600 includes receiving wastewater 610 through a wastewater inlet 110, or the like. The wastewater inlet 110, is configurable or configured to receive, provide, store or the like, the wastewater to be treated into the main treatment system 200. The wastewater to be treated may be from one or more sources including an area, catchment area, pond, and/or industrial wastewater generated from, but not limited to, semiconductor industry, and any other industries that may generate similar industrial wastewater. The method 600 (step 610) may also receive wastewater from one or more streams of rejected wastewater from one or more wastewater treatment processes and/or systems. The one or more wastewater streams or any other sources may include, but not limited to, wastewater stream with high concentration of copper, wastewater stream with high concentration of silica, wastewater stream with high concentration of copper, etc.

[0068] The method 600 also includes treating the wastewater 620. The wastewater may be treated by a main treatment system 200, which includes one or more membrane filtration assembly. The one or more membrane filtration assembly may be or include, but is not limited to, an automatic backwash filter system, an ultrafiltration system, a cartridge filtration system, a multimedia filtration, a membrane cartridge filtration, and any other suitable membrane filtration systems which may be used. The wastewater to be treated is received by a membrane filtration inlet 210 before directing the wastewater to one or more filtration membranes 220. The method 600 (step 620) provides includes a process of removing impurities, pollutants

and/or contaminants such as suspended or dissolved solids, particles, organic materials, sediments, etc. from the wastewater. The wastewater is passed through the one or more filtration membranes 220 to arrive at a treated wastewater and a rejected wastewater. The treated wastewater and the rejected wastewater are then directed to a membrane filtration outlet assembly 230. The membrane filtration outlet assembly 230 includes a treated water outlet 232 that is configurable or configured to manage a portion of the treated wastewater (e.g., a first portion of the treated wastewater). The membrane filtration outlet assembly 230 also includes a flushing water outlet 234 that is configurable or configured to manage a portion of the treated wastewater (e.g., a second portion of the treated wastewater). The membrane filtration outlet assembly 230 also includes a wastewater outlet 236 that is configurable or configured to manage the rejected wastewater.

[0069] The method 600 further includes storing the treated wastewater 630. The portion of the treated wastewater (e.g., a second portion of the treated wastewater) from the filtration membranes 220 is provided into a flushing assembly 300 via the flushing water outlet 234. The method includes directing the portion of the treated wastewater (e.g., a second portion of the treated wastewater) to be received by a flushing inlet 310. The portion of the treated wastewater (e.g., a second portion of the treated wastewater) is stored in a flushing storage 320 that is configurable or configured to receive and to store the portion of the treated wastewater (e.g., second portion of the treated wastewater). In an example, the flushing storage 320 in the method 600 (step 630) may store the portion of the treated wastewater (e.g., second portion of the treated wastewater) which may be provided to the main treatment system 200 during a membrane flushing process. The portion of the treated wastewater (e.g., second portion of the treated wastewater) is provided to the main treatment system 200 via a flushing outlet 330 when the main treatment system 200 transitions into a flushing state or when a determined saturation index based on one or more parameters of the wastewater and/or treated wastewater

that is treated by one or more elements of the wastewater treatment system 100 meets the trigger condition.

[0070] The method 600 further includes determining a saturation index 640. As disclosed in the present disclosure, the method 600 also includes managing the filtration membranes through membrane flushing process. The membrane flushing process occurs when the main treatment system 200 is transitioned from the treatment state to a flushing state. To initiate the transition, the method 600 determines whether a trigger condition for transitioning from the treatment state to the flushing state is achieved. The trigger condition is a saturation index of the wastewater to be treated and/or the treated wastewater. A saturation index in the present disclosure is a measure to be used to determine whether the wastewater or the treated water is saturated, under-saturated or oversaturated with respect to one or more elements such as pollutants, contaminants, minerals, or the like. For example, a high saturation index typically indicates that there is a possibility that membrane fouling, scaling, and/or corrosion has occurred or formed in the treatment system particularly in the filtration membranes. A reduction in permeate flux and/or inefficient removal of contaminants or pollutants from the wastewater are some examples that may be seen when a saturation index is high. As such, a membrane flushing process (e.g., transitioning to a flushing state) may be required.

[0071] The saturation index that is determined in the method 600 (e.g., step 640) is based on one or more parameters of the wastewater and/or treated wastewater that is treated by one or more elements of the wastewater treatment system 100. The saturation index is determined at one or more locations including an upstream input of the wastewater inlet, a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet and/or a downstream output of the membrane filtration inlet.

[0072] In an exemplary embodiment, the main controller 500 in the method 600 (e.g., step 640) may receive measurements of parameters such as, but not limited to, a fluoride (F) content in

the wastewater to be treated, a silicon dioxide (SiO_2) content in the wastewater to be treated, a calcium (Ca) content in the wastewater to be treated, and/or the alkalinity of the wastewater that is to be treated when determining the saturation index.

[0073] The main controller 500 may also receive an alkalinity of the wastewater to be treated, a water permeability of the wastewater to be treated, and a salt permeability of the wastewater to be treated when determining the saturation index. Further, a water permeability of the treated wastewater, a water permeability of the portion of the treated wastewater that is received by the flushing assembly 300, a salt permeability of the treated wastewater, and a salt permeability of the portion of the treated wastewater that is received by the flushing assembly may also be measured to determine the saturation index.

[0074] When determining a saturation index 640, one or more sensors and/or analyzers may be present and configurable or configured to measure the values of the parameters as disclosed above. The one or more sensors and/or analyzers measure the values of the parameters including the pH, fluoride concentration or content, calcium concentration or content, water permeability, etc. of the wastewater to be treated and the treated wastewater in the wastewater treatment system 100.

[0075] Examples of sensors and/or analyzers that may be used to monitor and measure the values are, but not limited to, pH sensors, total suspended solids sensors, substance detection sections, ion selective sensors, etc. These sensors and/or analyzers send the measured values to the main controller 500 for further processing and determination on whether the saturation index (e.g. step 640) that is based on these measured parameter values meets the trigger condition.

[0076] For example, the main controller 500 may receive one or more values of the parameters as measured at the one or more disclosed locations. With the values obtained, the main controller 500 may compare these values with historical or predetermined values of the one or

more parameters to arrive at a determination on whether the saturation index meets the trigger condition.

[0077] Alternatively, the saturation index may be calculated and determined using formulas or algorithms using one or more measured parameter values. Alternatively, the saturation index may also be calculated and determined through external sources using the measured parameter values. The determined saturation index is then provided or input in the system for further processing. Once a saturation index is determined, the main controller 500 is configurable or configured to determine if the saturation index is within the threshold or range of a trigger condition (e.g., to transition to a flushing state).

[0078] The method 600 further includes flushing of filtration membranes 650. When it is determined that the saturation index falls within the threshold or range of a trigger condition, the trigger condition is met and the main controller 500 is configured to transition the main treatment assembly 200 from the treatment state to a flushing state. The main controller 500 may also provide at least one command to the input selector 400 to transition from the treatment state to a flushing state.

[0079] When in a flushing state, the main controller 500 in method 600 (e.g., step 650) communicates with the flushing outlet 330 to provide or direct the portion of treated wastewater (e.g., second portion of treated wastewater) from the flushing storage 320 to the membrane filtration inlet 210. At the same time, the main controller 500 is also in communication with the wastewater inlet 110 to not provide or direct the wastewater to the membrane filtration inlet 210 of the main treatment system 200. The portion of treated wastewater as received by the membrane filtration inlet 210 is provided to the one or more filtration membranes 220 to undergo the membrane flushing process. The membrane flushing process of the one or more filtration membranes 220 in method 600 (e.g., step 650) allows the treated wastewater to force through the filtration membranes 220 causing the pores of the membranes to be cleaned or

flushed of any particles or contaminants that are present. The membrane flushing process also removes constructed layer of contaminants from wastewater treatment.

[0080] The membrane flushing process may be, but not limited to, forward flush, backward flush, etc. and/or a combination thereof. The main controller 500 further transitions the main treatment assembly 200 to remain in the flushing state for a period of time (e.g., between 10 seconds to 120 seconds, or more or less) when in the flushing state. Further, the flow rate of the portion of treated wastewater from the flushing assembly 300 into the membrane filtration inlet 310 to clean the filtration membranes 320 is controlled or maintained to be between 20% to 100%.

[0081] While various embodiments in accordance with the disclosed principles have been described above, it should be understood that they have been presented by way of example only and are not limiting. Thus, the breadth and scope of the example embodiments described in the present disclosure should not be limited by any of the above-described exemplary embodiments but should be defined only in accordance with the claims and their equivalents issuing from this disclosure. Furthermore, the above advantages and features are provided in described embodiments but shall not limit the application of such issued claims to processes and structures accomplishing any or all of the above advantages.

[0082] Various terms used herein have special meanings within the present technical field. Whether a particular term should be construed as such a "term of art" depends on the context in which that term is used. Such terms are to be construed in light of the context in which they are used in the present disclosure and as one of ordinary skill in the art would understand those terms in the disclosed context. The above definitions are not exclusive of other meanings that might be imparted to those terms based on the disclosed context.

[0083] Additionally, the section headings and topic headings herein are provided for consistency with the suggestions under various patent regulations and practice, or otherwise to

provide organizational cues. These headings shall not limit or characterize the embodiments set out in any claims that may issue from this disclosure. Specifically, a description of a technology in the "Background" is not to be construed as an admission that technology is prior art to any embodiments in this disclosure. Furthermore, any reference in this disclosure to "invention" in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple inventions may be set forth according to the limitations of the claims issuing from this disclosure, and such claims accordingly define the invention(s), and their equivalents, that are protected thereby. In all instances, the scope of such claims shall be considered on their own merits in light of this disclosure, but should not be constrained by the headings herein.

Claims

What is claimed is:

1. A wastewater treatment system, the wastewater treatment system comprising:
 - a wastewater inlet, the wastewater inlet configured to receive wastewater;
 - a main treatment assembly, the main treatment assembly including:
 - a membrane filtration assembly, the membrane filtration assembly including:
 - a membrane filtration inlet;
 - one or more filtration membranes, the one or more filtration membranes configured to receive an input from the membrane filtration inlet and treat the input, wherein, when the input from the membrane filtration inlet is wastewater from the wastewater inlet, the one or more filtration membranes are configured to treat the wastewater to arrive at a treated wastewater portion and a rejected wastewater portion; and
 - a membrane filtration outlet assembly, the membrane filtration outlet assembly including:
 - a treated water outlet, the treated water outlet configured to manage a first portion of the treated wastewater portion from the one or more filtration membranes;
 - a flushing water outlet, the flushing water outlet configured to manage a second portion of the treated wastewater portion from the one or more filtration membranes; and
 - a wastewater outlet, the wastewater outlet configured to manage the rejected wastewater portion from the one or more filtration members;
 - a flushing assembly, the flushing assembly including:
 - a flushing inlet and flushing outlet; and

a flushing storage assembly, the flushing storage assembly configured to receive, via the flushing inlet, the second portion of the treated wastewater portion from the flushing water outlet and store the received second portion of the treated wastewater portion; and

an input selector, the input selector provided between a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and a downstream output of the flushing outlet, the input selector configured to transition between a treatment state and a flushing state, wherein:

the treatment state is a state in which the input selector selectively enables fluid communication from the wastewater inlet to the membrane filtration inlet in such a way as to enable the one or more filtration membranes to receive, as the input, wastewater from the membrane filtration inlet;

the flushing state is a state in which the input selector selectively enables fluid communication from the flushing outlet of the flushing assembly to the membrane filtration inlet in such a way as to enable the one or more filtration membranes to receive, as the input, the second portion of the treated wastewater portion stored in the flushing storage assembly; and

the input selector transitions from the treatment state to the flushing state based on a determination of a trigger condition, wherein:

the trigger condition for transitioning the input selector from the treatment state to the flushing state is a saturation index of the wastewater that is to be treated by the main treatment assembly.

2. The wastewater treatment system of claim 1,

wherein, when the input from the membrane filtration inlet is the second portion of the treated wastewater portion from the flushing outlet, the second portion of the treated

wastewater portion performs a flushing of the one or more filtration membranes so as to clean the one or more filtration membranes.

3. The wastewater treatment system of claim 1,
wherein, when the input selector is in the treatment state, the input selector does not enable fluid communication from the flushing outlet of the flushing assembly to the membrane filtration inlet.

4. The wastewater treatment system of claim 1,
wherein, when the input selector is in the flushing state, the input selector does not enable fluid communication from the wastewater inlet to the membrane filtration inlet.

5. The wastewater treatment system of claim 1,
wherein a default state of the input selector is the treatment state.

6. The wastewater treatment system of claim 1, further comprising:
a wastewater controller, the wastewater controller configured to determine whether or not the trigger condition has been met;

wherein, when the wastewater controller determines that the trigger condition has been met, the wastewater controller is configured to selectively control the input selector to transition from the treatment state to the flushing state.

7. The wastewater treatment system of claim 1,
wherein the saturation index of the wastewater is measured at one or more of the following locations:

- an upstream input of the wastewater inlet;
- the downstream output of the wastewater inlet;
- the upstream input of the membrane filtration inlet; and/or
- a downstream output of the membrane filtration inlet.

8. The wastewater treatment system of claim 1,

wherein the saturation index is determined based on at least one of the following:

a fluoride (F) content of the wastewater that is to be treated by the main treatment assembly;

a silicon dioxide (SiO_2) content of the wastewater that is to be treated by the main treatment assembly;

an alkalinity of the wastewater that is to be treated by the main treatment assembly;

a calcium (Ca) content of the wastewater that is to be treated by the main treatment assembly;

a pressure differential between the wastewater that is to be treated by the main treatment assembly and the first portion of the treated wastewater portion from the treated water outlet;

a water permeability of the wastewater that is to be treated by the main treatment assembly;

a water permeability of the first portion of the treated wastewater portion from the treated water outlet that has been treated by the main treatment assembly;

a water permeability of the second portion of the treated wastewater portion from the flushing water outlet that has been treated by the main treatment assembly;

a salt permeability of the wastewater that is to be treated by the main treatment assembly;

a salt permeability of the first portion of the treated wastewater portion from the treated water outlet that has been treated by the main treatment assembly; and/or

a salt permeability of the second portion of the treated wastewater portion from the flushing outlet that has been treated by the main treatment assembly.

9. The wastewater treatment system of claim 1,

wherein the one or more filtration membranes include:

- a nanofiltration membrane;
- a reverse osmosis (RO) membrane;
- osmosis (BWRO) membranes;
- sea water reverse osmosis (SWRO) membranes;
- and others.

10. The wastewater treatment system of claim 1,
wherein, when the input selector is transitioned from the treatment state to the flushing state, at least one of the following apply:

- the input selector remains in the flushing state for between 10 seconds to 120 seconds; and/or

- a flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet is between 20% to 100%.

11. A wastewater treatment system, the wastewater treatment system comprising:

- a wastewater inlet, the wastewater inlet configured to receive wastewater;

- a main treatment assembly, the main treatment assembly including:

- a membrane filtration assembly, the membrane filtration assembly including:

- a membrane filtration inlet; and

- one or more filtration membranes, the one or more filtration membranes configured to treat wastewater received by the membrane filtration inlet;

- a flushing assembly, the flushing assembly configured to receive a portion of the treated wastewater from the one or more filtration membranes and store the received portion of the treated wastewater; and

an input selector, the input selector provided between the wastewater inlet, the membrane filtration inlet, and the flushing assembly, the input selector configured to transition between a treatment state and a flushing state, wherein:

the treatment state is a state in which the input selector selectively enables fluid communication from the wastewater inlet to the membrane filtration inlet;

the flushing state is a state in which the input selector selectively enables fluid communication from the flushing assembly to the membrane filtration inlet; and

the input selector transitions from the treatment state to the flushing state based on a determination of a trigger condition, wherein:

the trigger condition for transitioning the input selector from the treatment state to the flushing state is a saturation index of the wastewater that is to be treated by the main treatment assembly.

12. The wastewater treatment system of claim 11,

wherein, when the membrane filtration inlet receives the portion of the treated wastewater portion from the flushing assembly, the portion of the treated wastewater portion performs a flushing of the one or more filtration membranes so as to clean the one or more filtration membranes.

13. The wastewater treatment system of claim 11,

wherein, when the input selector is in the treatment state, the input selector does not enable fluid communication from the flushing assembly to the membrane filtration inlet.

14. The wastewater treatment system of claim 11,

wherein, when the input selector is in the flushing state, the input selector does not enable fluid communication from the wastewater inlet to the membrane filtration inlet.

15. The wastewater treatment system of claim 11,

wherein a default state of the input selector is the treatment state.

16. The wastewater treatment system of claim 11, further comprising:
- a wastewater controller, the wastewater controller configured to determine whether or not the trigger condition has been met;
 - wherein, when the wastewater controller determines that the trigger condition has been met, the wastewater controller is configured to selectively control the input selector to transition from the treatment state to the flushing state.
17. The wastewater treatment system of claim 11,
- wherein the saturation index of the wastewater is measured at one or more of the following locations:
 - an upstream input of the wastewater inlet;
 - a downstream output of the wastewater inlet;
 - a upstream input of the membrane filtration inlet; and/or
 - a downstream output of the membrane filtration inlet.
18. The wastewater treatment system of claim 11,
- wherein the saturation index is determined based on at least one of the following:
 - a fluoride (F) content of the wastewater that is to be treated by the main treatment assembly;
 - a silicon dioxide (SiO₂) content of the wastewater that is to be treated by the main treatment assembly;
 - an alkalinity of the wastewater that is to be treated by the main treatment assembly;
 - a calcium (Ca) content of the wastewater that is to be treated by the main treatment assembly;
 - a pressure differential between the wastewater that is to be treated by the main treatment assembly and the treated wastewater;

a water permeability of the wastewater that is to be treated by the main treatment assembly;

a water permeability of the treated wastewater that has been treated by the main treatment assembly;

a water permeability of the portion of the treated wastewater that is received by the flushing assembly;

a salt permeability of the wastewater that is to be treated by the main treatment assembly;

a salt permeability of the treated wastewater portion that has been treated by the main treatment assembly; and/or

a salt permeability of the portion of the treated wastewater that is received by the flushing assembly.

19. The wastewater treatment system of claim 11,

wherein the one or more filtration membranes include:

a nanofiltration membrane;

a reverse osmosis (RO) membrane;

osmosis (BWRO) membranes;

sea water reverse osmosis (SWRO) membranes;

and others.

20. The wastewater treatment system of claim 11,

wherein, when the input selector is transitioned from the treatment state to the flushing state, at least one of the following apply:

the input selector remains in the flushing state for between 10 seconds to 120 seconds; and/or

a flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet is between 20% to 100%.

21. A wastewater treatment system, the wastewater treatment system comprising:

a wastewater inlet, the wastewater inlet configured to receive wastewater;

a main treatment assembly, the main treatment assembly including:

a membrane filtration assembly, the membrane filtration assembly including:

a membrane filtration inlet; and

one or more filtration membranes, the one or more filtration membranes configured to treat wastewater received by the membrane filtration inlet;

a flushing assembly, the flushing assembly configured to receive a portion of the treated wastewater from the one or more filtration membranes and store the received portion of the treated wastewater; and

a main controller, the main controller configured to transition the main treatment assembly between a treatment state and a flushing state, wherein:

the treatment state is a state in which the membrane filtration inlet receives fluid communication from the wastewater inlet;

the flushing state is a state in which the membrane filtration inlet receives fluid communication from the flushing assembly; and

the main controller transitions the main treatment assembly from the treatment state to the flushing state based on a determination of a trigger condition, wherein:

the trigger condition for transitioning the main treatment assembly from the treatment state to the flushing state is a saturation index of the wastewater that is to be treated by the main treatment assembly.

22. The wastewater treatment system of claim 23,

wherein, when the membrane filtration inlet receives the portion of the treated wastewater portion from the flushing assembly during the flushing state, the received portion of the treated wastewater portion performs a flushing of the one or more filtration membranes so as to clean the one or more filtration membranes.

23. The wastewater treatment system of claim 21,

wherein, when the main controller transitions the main treatment assembly to be in the treatment state, the main controller stops fluid communication from the flushing assembly to the membrane filtration inlet.

24. The wastewater treatment system of claim 21,

wherein, when the main controller is in the flushing state, the main controller stops fluid communication from the wastewater inlet to the membrane filtration inlet.

25. The wastewater treatment system of claim 21, further comprising:

an input selector, the input selector provided between the wastewater inlet, the membrane filtration inlet, and the flushing assembly, the input selector configured receive commands from the main controller to transition the main treatment assembly between the treatment state and the flushing state.

26. The wastewater treatment system of claim 21,

wherein a default state is the treatment state.

27. The wastewater treatment system of claim 21,

wherein the saturation index of the wastewater is measured at one or more of the following locations:

an upstream input of the wastewater inlet;

a downstream output of the wastewater inlet;

a upstream input of the membrane filtration inlet; and/or

a downstream output of the membrane filtration inlet.

28. The wastewater treatment system of claim 21,

wherein the saturation index is determined based on at least one of the following:

a fluoride (F) content of the wastewater that is to be treated by the main treatment assembly;

a silicon dioxide (SiO₂) content of the wastewater that is to be treated by the main treatment assembly;

an alkalinity of the wastewater that is to be treated by the main treatment assembly;

a calcium (Ca) content of the wastewater that is to be treated by the main treatment assembly;

a pressure differential between the wastewater that is to be treated by the main treatment assembly and the treated wastewater;

a water permeability of the wastewater that is to be treated by the main treatment assembly;

a water permeability of the treated wastewater that has been treated by the main treatment assembly;

a water permeability of the portion of the treated wastewater that is received by the flushing assembly;

a salt permeability of the wastewater that is to be treated by the main treatment assembly;

a salt permeability of the treated wastewater portion that has been treated by the main treatment assembly; and/or

a salt permeability of the portion of the treated wastewater that is received by the flushing assembly.

29. The wastewater treatment system of claim 23,

wherein the one or more filtration membranes include:

- a nanofiltration membrane;
- a reverse osmosis (RO) membrane;
- osmosis (BWRO) membranes;
- sea water reverse osmosis (SWRO) membranes;
- and others.

30. The wastewater treatment system of claim 21,

wherein, when the main controller transitions the main treatment assembly from the treatment state to the flushing state, at least one of the following apply:

the main treatment assembly remains in the flushing state for between 10 seconds to 120 seconds; and/or

a flow rate of the portion of the treated wastewater from the flushing assembly into the membrane filtration inlet is between 20% to 100%.

31. A wastewater treatment system, the wastewater treatment system comprising:

a wastewater inlet, the wastewater inlet configured to receive wastewater;

a main treatment assembly, the main treatment assembly including:

a membrane filtration assembly, the membrane filtration assembly including:

a membrane filtration inlet;

one or more filtration membranes, the one or more filtration membranes configured to receive an input from the membrane filtration inlet and treat the input, wherein, when the input from the membrane filtration inlet is wastewater from the wastewater inlet, the one or more filtration membranes are configured to treat the wastewater to arrive at a treated wastewater portion and a rejected wastewater portion; and

a membrane filtration outlet assembly, the membrane filtration outlet assembly including:

a treated water outlet, the treated water outlet configured to manage a first portion of the treated wastewater portion from the one or more filtration membranes;

a flushing water outlet, the flushing water outlet configured to manage a second portion of the treated wastewater portion from the one or more filtration membranes; and

a wastewater outlet, the wastewater outlet configured to manage the rejected wastewater portion from the one or more filtration members;

a flushing assembly, the flushing assembly including:

a flushing inlet and flushing outlet; and

a flushing storage assembly, the flushing storage assembly configured to receive, via the flushing inlet, the second portion of the treated wastewater portion from the flushing water outlet and store the received second portion of the treated wastewater portion; and

an input selector, the input selector provided between a downstream output of the wastewater inlet, an upstream input of the membrane filtration inlet, and a downstream output of the flushing outlet, the input selector configured to transition between a treatment state and a flushing state, wherein:

the treatment state is a state in which the input selector selectively enables fluid communication from the wastewater inlet to the membrane filtration inlet in such a way as to enable the one or more filtration membranes to receive, as the input, wastewater from the membrane filtration inlet;

the flushing state is a state in which the input selector selectively enables fluid communication from the flushing outlet of the flushing assembly to the membrane filtration

inlet in such a way as to enable the one or more filtration membranes to receive, as the input, the second portion of the treated wastewater portion stored in the flushing storage assembly;

the input selector transitions from the treatment state to the flushing state based on a determination of a trigger condition;

wherein the trigger condition for transitioning the input selector from the treatment state to the flushing state is a saturation index of the wastewater that is to be treated by the main treatment assembly; and

when the input selector is transitioned from the treatment state to the flushing state, at least one of the following apply:

the input selector remains in the flushing state for between 10 seconds to 120 seconds; and/or

a flow rate of the second portion of the treated wastewater portion into the membrane filtration inlet is between 20% to 100%.

32. The wastewater treatment system of claim 31,

wherein, when the input from the membrane filtration inlet is the second portion of the treated wastewater portion from the flushing outlet, the second portion of the treated wastewater portion performs a flushing of the one or more filtration membranes so as to clean the one or more filtration membranes.

33. The wastewater treatment system of claim 31,

wherein, when the input selector is in the treatment state, the input selector does not enable fluid communication from the flushing outlet of the flushing assembly to the membrane filtration inlet.

34. The wastewater treatment system of claim 31,

wherein, when the input selector is in the flushing state, the input selector does not enable fluid communication from the wastewater inlet to the membrane filtration inlet.

35. The wastewater treatment system of claim 31,
wherein a default state of the input selector is the treatment state.
36. The wastewater treatment system of claim 31,
wherein the saturation index of the wastewater is measured at one or more of the following locations:
- an upstream input of the wastewater inlet;
 - the downstream output of the wastewater inlet;
 - the upstream input of the membrane filtration inlet; and/or
 - a downstream output of the membrane filtration inlet.
37. The wastewater treatment system of claim 31,
wherein the saturation index is determined based on at least one of the following:
- a fluoride (F) content of the wastewater that is to be treated by the main treatment assembly;
 - a silicon dioxide (SiO₂) content of the wastewater that is to be treated by the main treatment assembly;
 - an alkalinity of the wastewater that is to be treated by the main treatment assembly;
 - a calcium (Ca) content of the wastewater that is to be treated by the main treatment assembly;
 - a pressure differential between the wastewater that is to be treated by the main treatment assembly and the first portion of the treated wastewater portion from the treated water outlet;
 - a water permeability of the wastewater that is to be treated by the main treatment assembly;

a water permeability of the first portion of the treated wastewater portion from the treated water outlet that has been treated by the main treatment assembly;

a water permeability of the second portion of the treated wastewater portion from the flushing water outlet that has been treated by the main treatment assembly;

a salt permeability of the wastewater that is to be treated by the main treatment assembly;

a salt permeability of the first portion of the treated wastewater portion from the treated water outlet that has been treated by the main treatment assembly; and/or

a salt permeability of the second portion of the treated wastewater portion from the flushing outlet that has been treated by the main treatment assembly.

38. The wastewater treatment system of claim 31,

wherein the one or more filtration membranes include:

a nanofiltration membrane;

a reverse osmosis (RO) membrane;

osmosis (BWRO) membranes;

sea water reverse osmosis (SWRO) membranes;

and others.