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(54) **SYSTEM AND METHOD FOR SEPARATING NUTRIENTS FROM A WASTE STREAM**

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(52) **U.S. Cl.**

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(57) **ABSTRACT**

A system and method to separate and concentrate nutrients from process waste water comprising the steps of accumulating the process waste water in a settling tank; settling the solids to form a supernatant and settled sludge; filtering the supernatant with a filtration system to form a permeate and a concentrate; dewatering the settled sludge to form thickened solids and a pressate; and, blending the thickened solids and the concentrate to form a slurry.

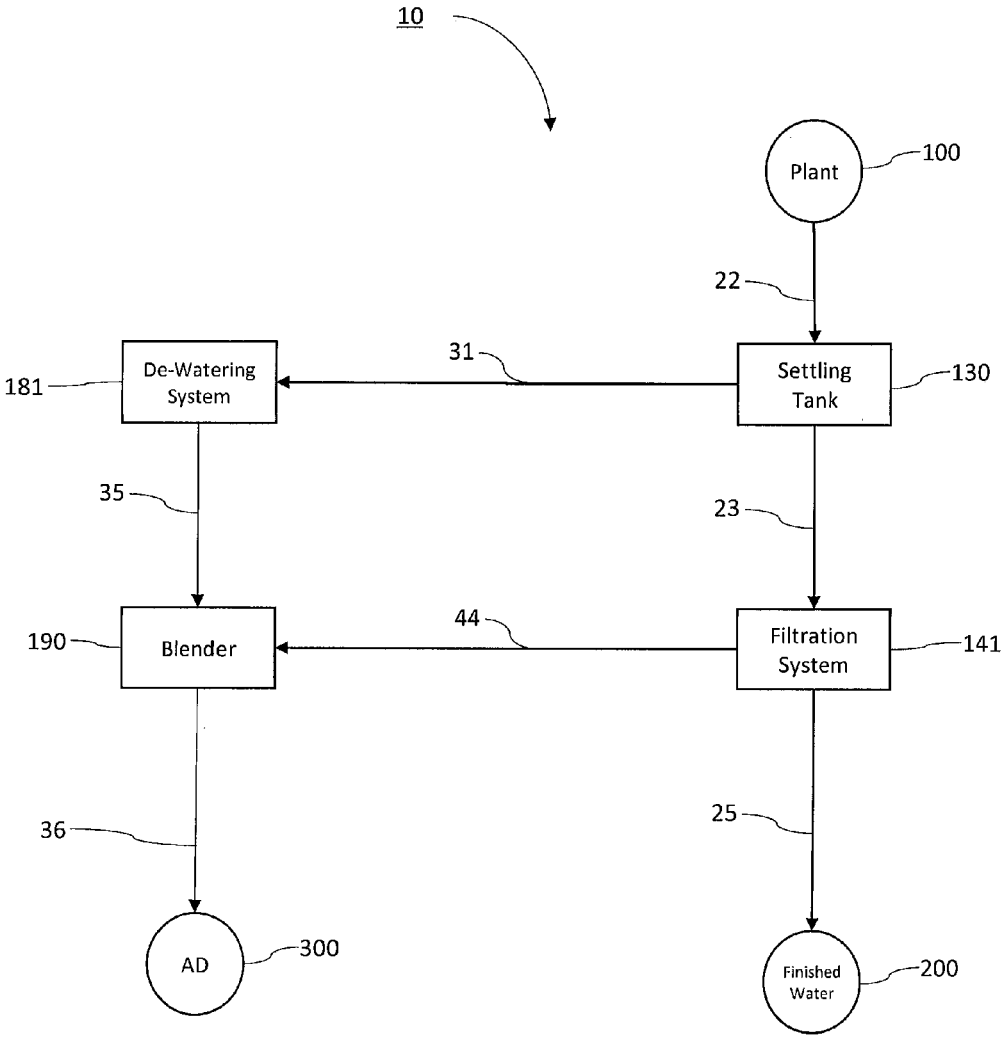


FIG. 1

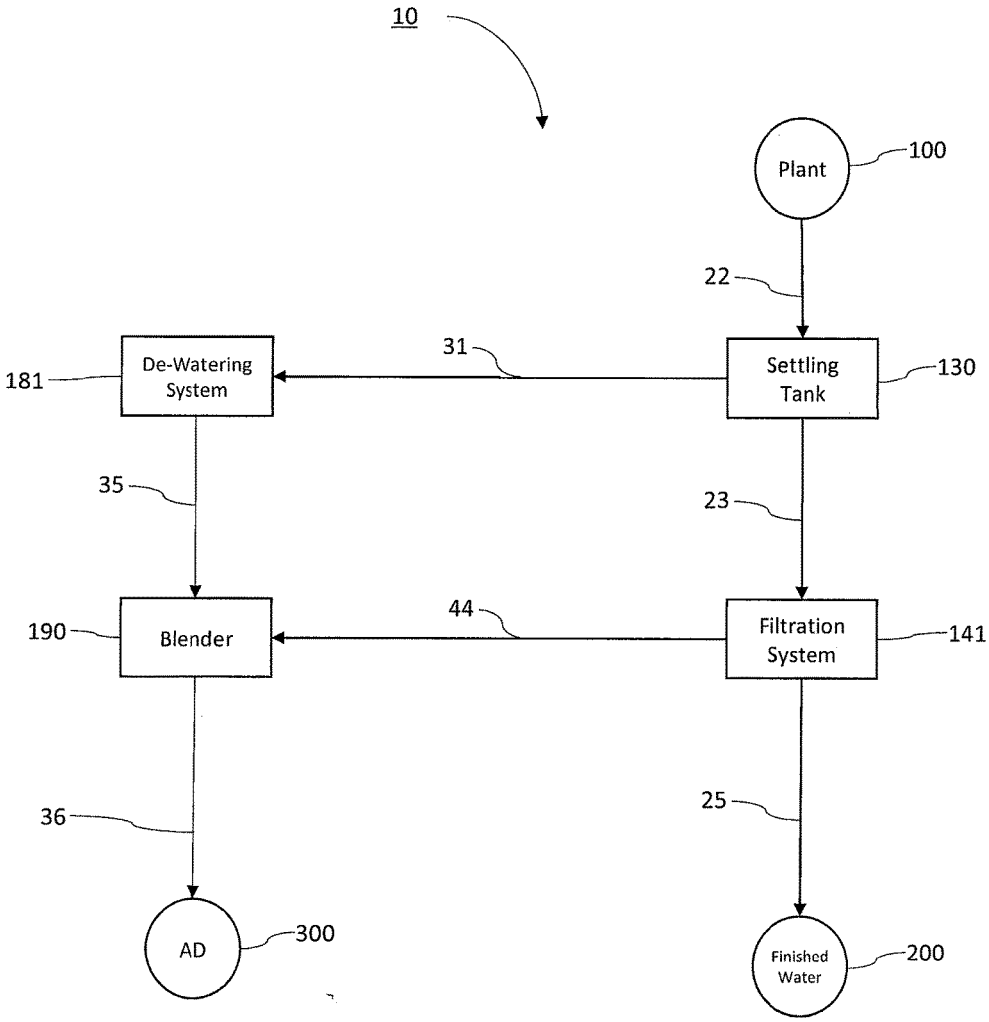

10
Plant
100
22
31
De-Watering System
181
Settling Tank
130
35
23
190
Blender
44
Filtration System
141
36
25
AD
300
Finished Water
200

FIG. 2

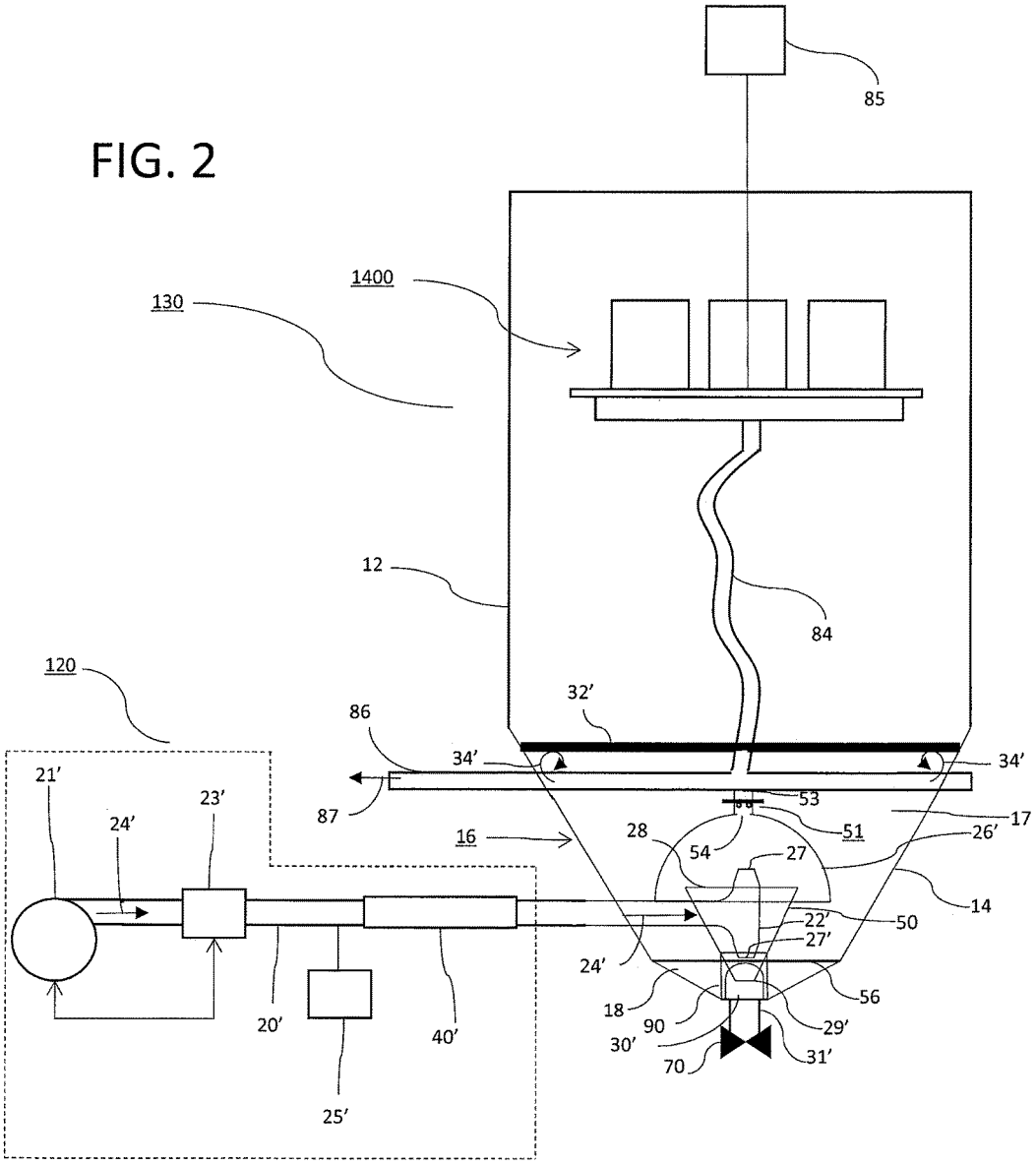

85
1400
130
12
84
120
32'
86
34'
34'
87
53
17
16
28
54
27
51
26'
14
22'
50
27'
24'
56
18
90
29'
30'
31'
70
21'
24'
23'
20'
40'
25'

FIG. 3

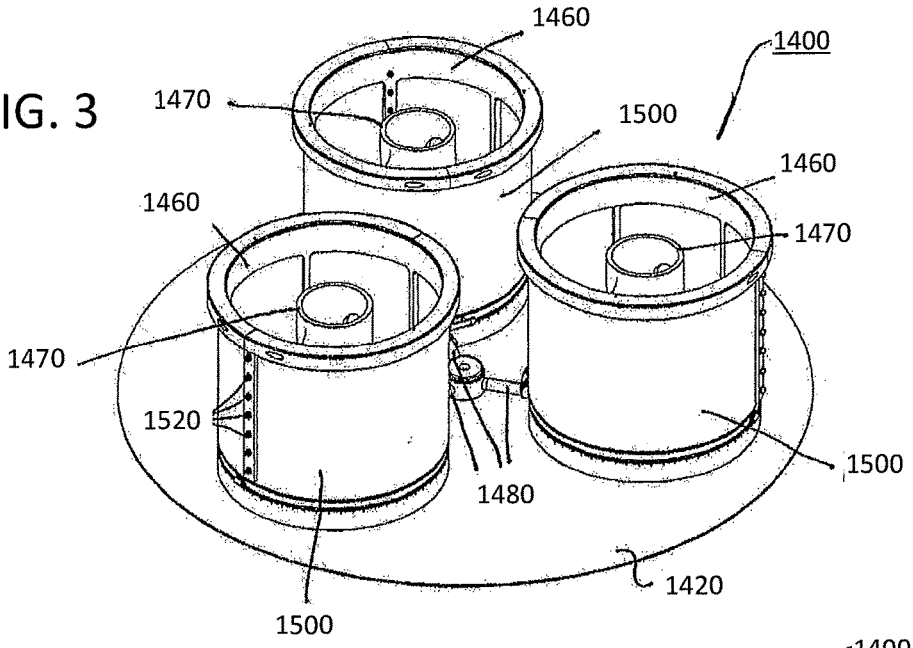

1460
1400
1470
1500
1460
1460
1470
1470
1520
1500
1480
1420
1500

FIG. 4

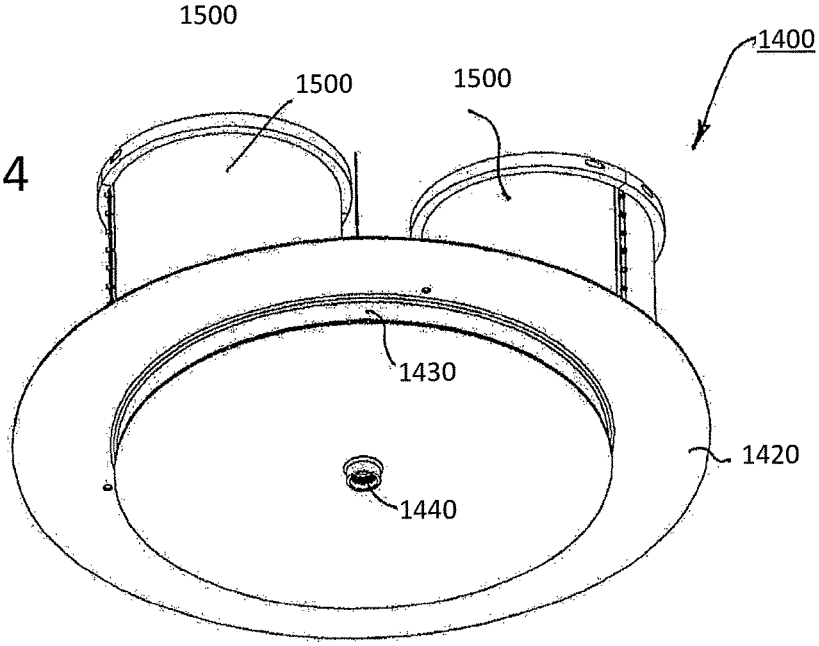

1400
1500
1500
1430
1420
1440

FIG. 5

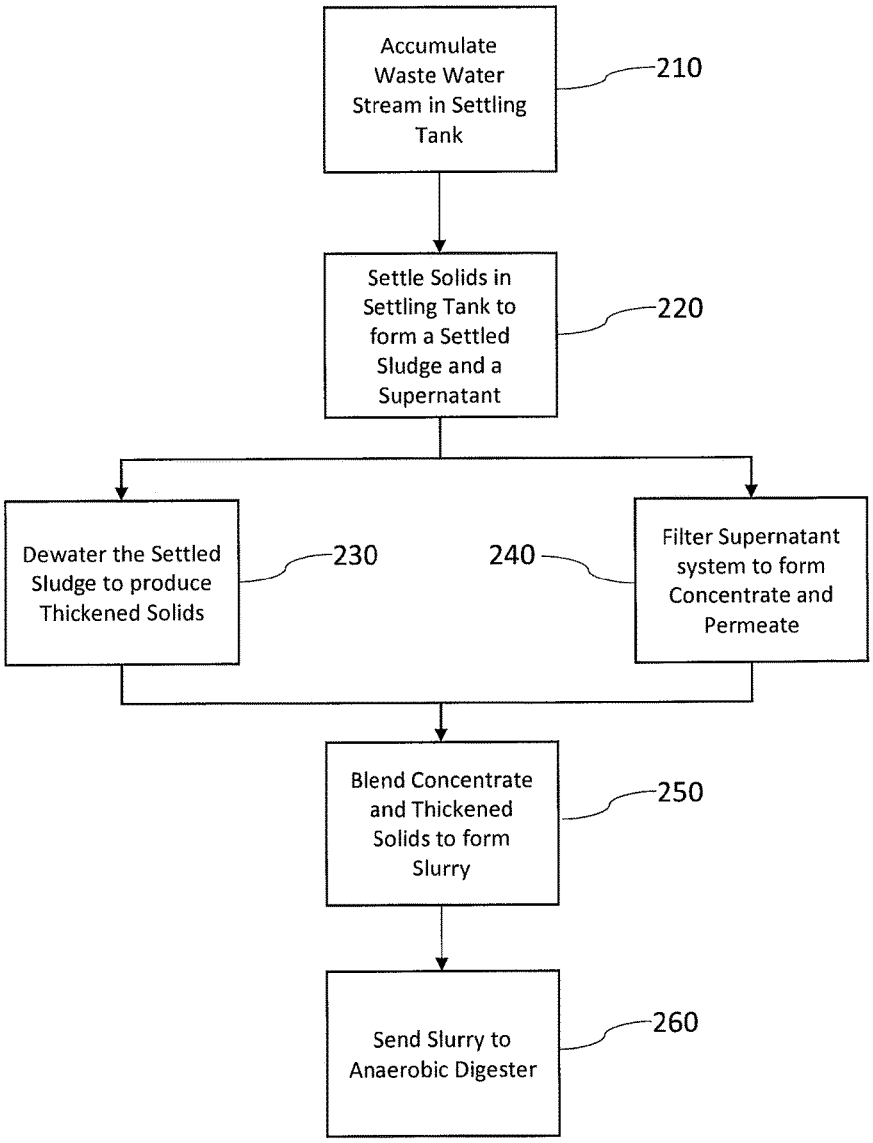

Accumulate Waste Water Stream in Settling Tank
210
Settle Solids in Settling Tank to form a Settled Sludge and a Supernatant
220
Dewater the Settled Sludge to produce Thickened Solids
230
240
Filter Supernatant system to form Concentrate and Permeate
Blend Concentrate and Thickened Solids to form Slurry
250
Send Slurry to Anaerobic Digester
260

FIG. 6

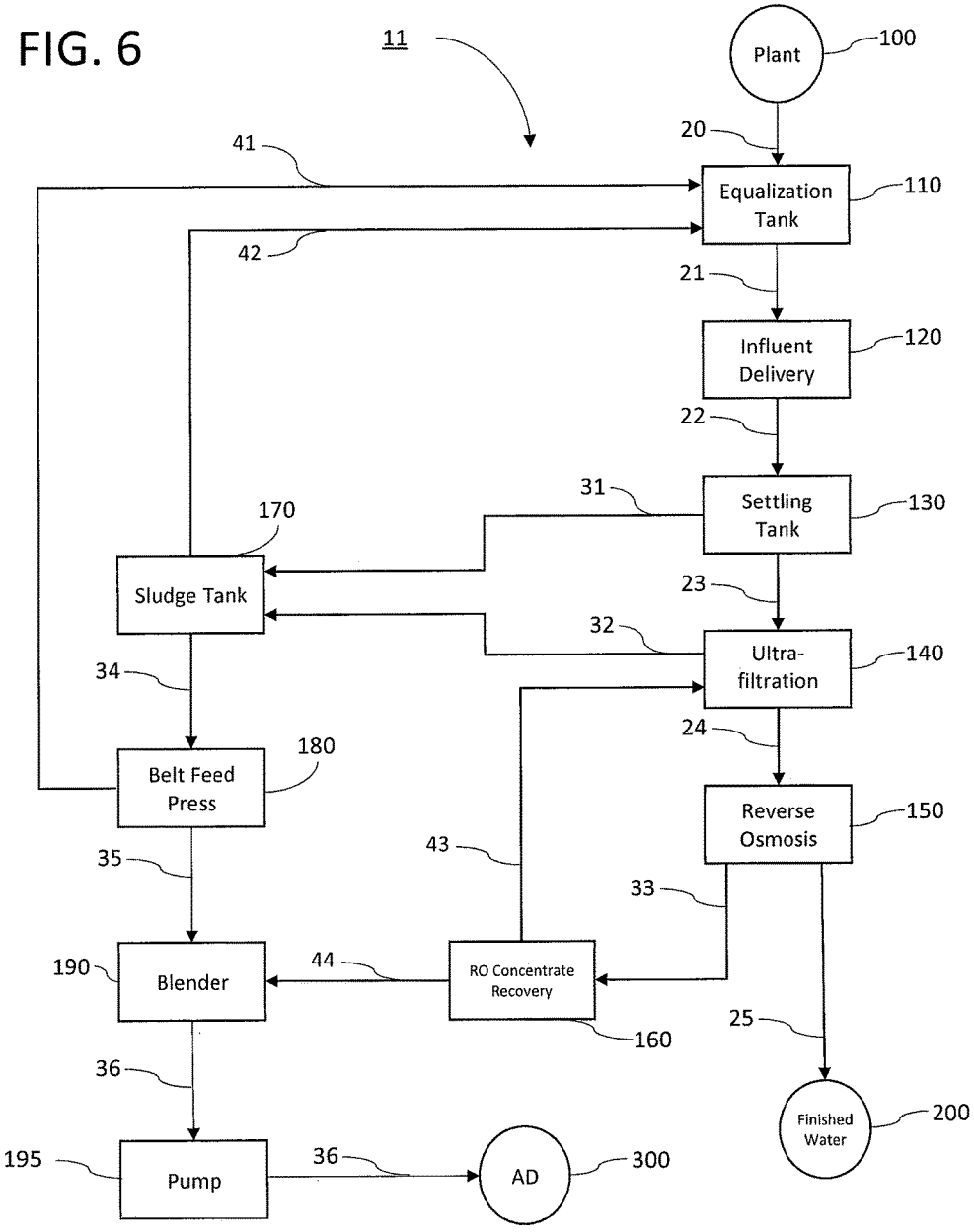

11
Plant
100
20
41
Equalization Tank
110
42
21
Influent Delivery
120
22
31
Settling Tank
130
170
Sludge Tank
23
32
Ultra-filtration
140
34
24
180
Belt Feed Press
Reverse Osmosis
150
43
35
33
190
Blender
44
RO Concentrate Recovery
160
25
36
Finished Water
200
195
Pump
36
AD
300

FIG. 7

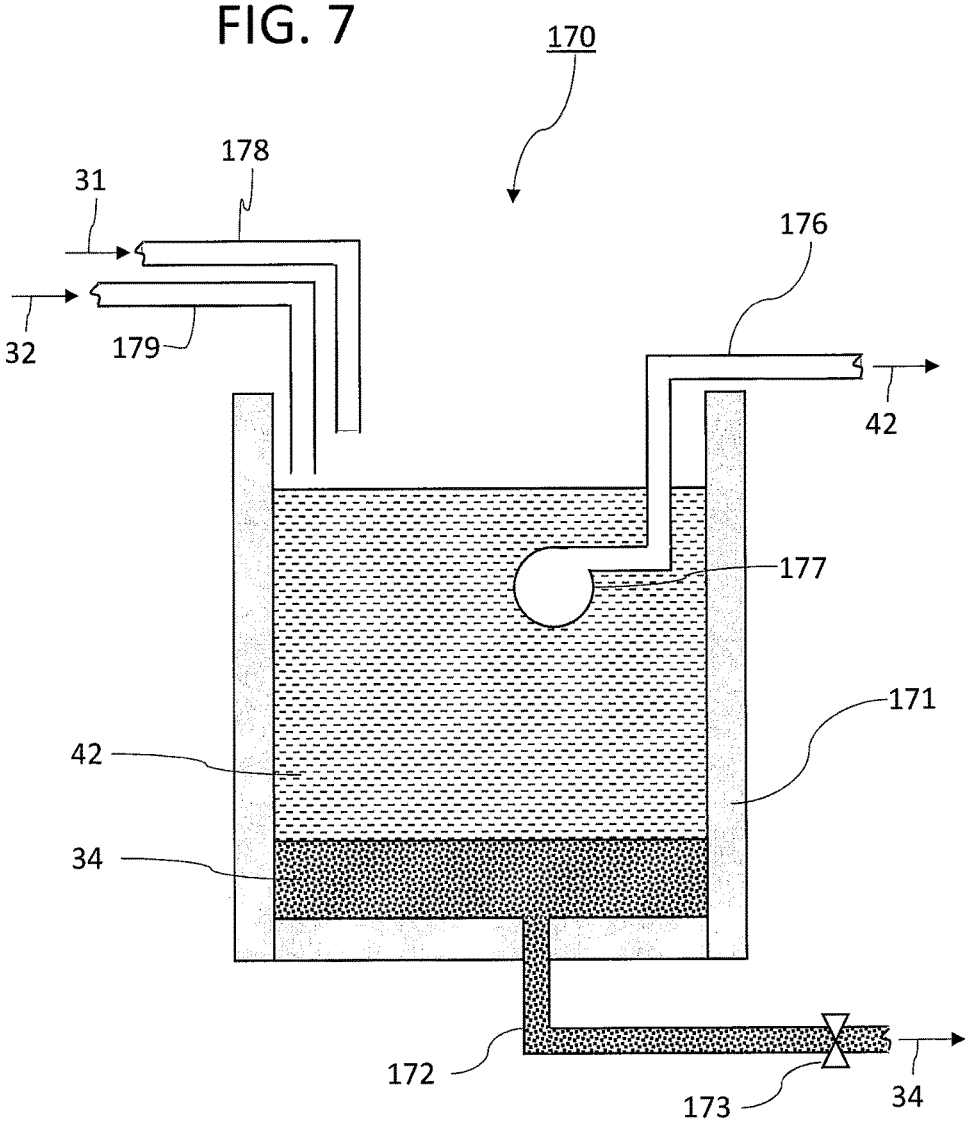


FIG. 8

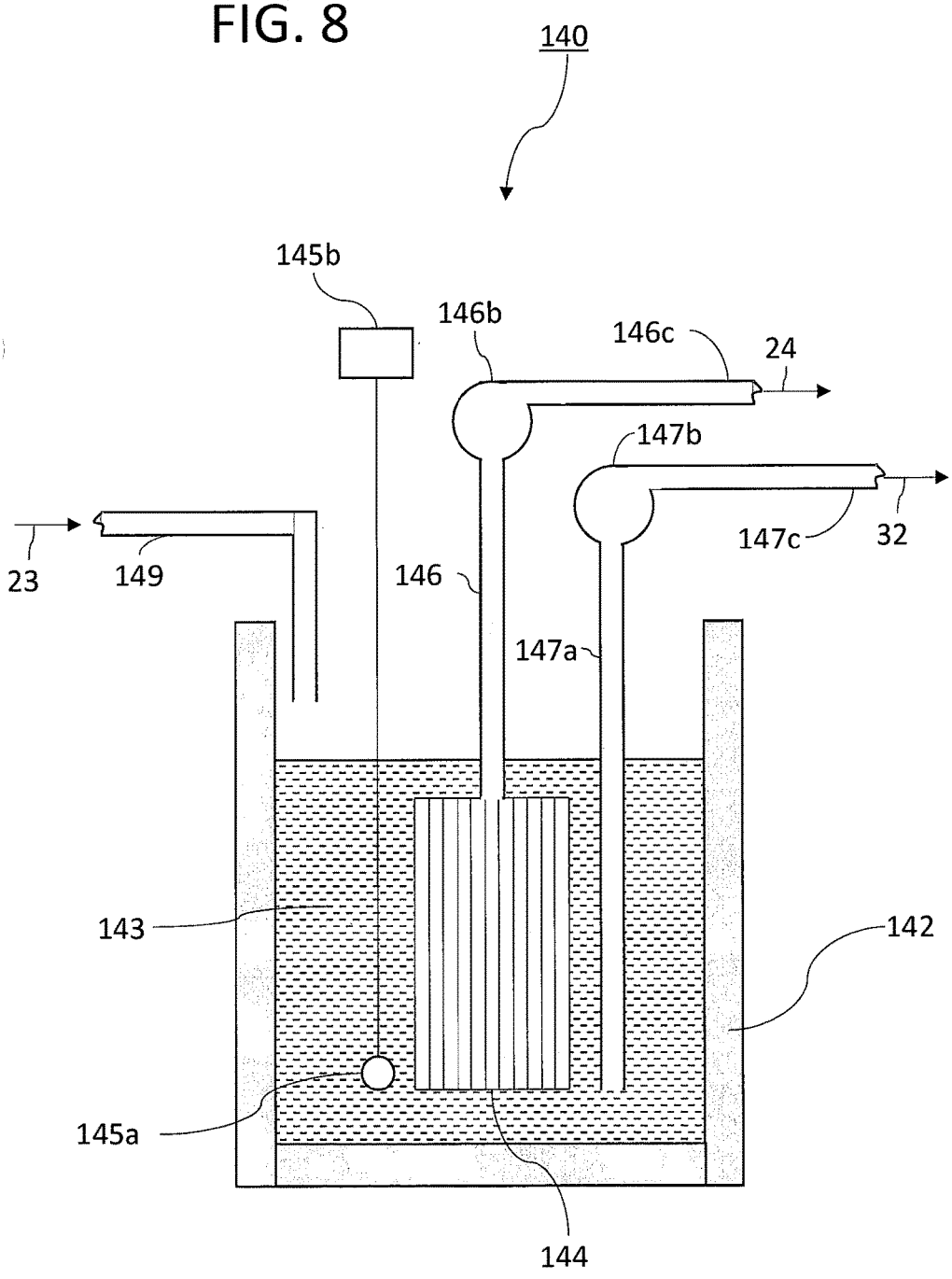
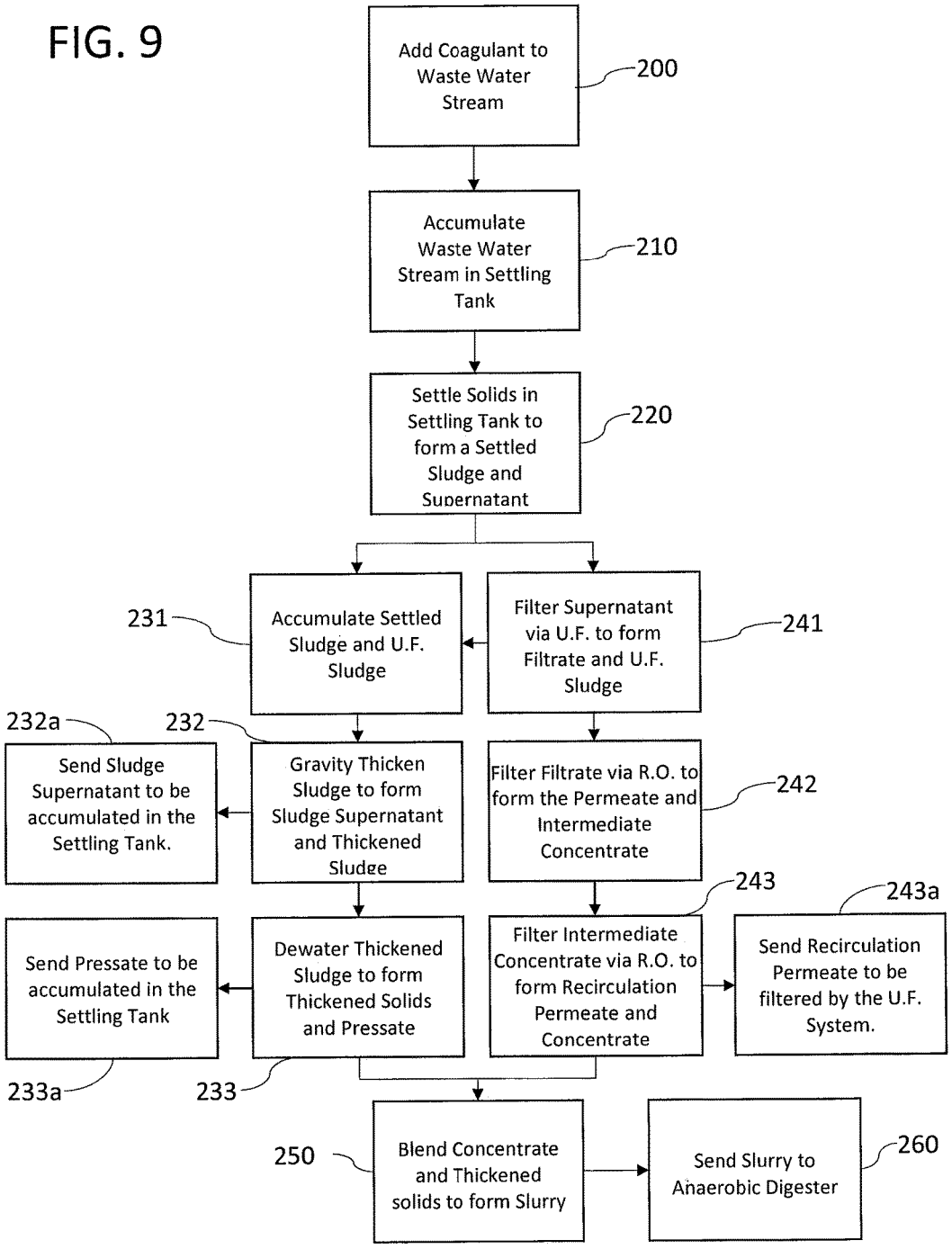

140
145b
146b
146c
24
147b
147c
32
23
149
146
147a
143
142
145a
144

FIG. 9


Add Coagulant to Waste Water Stream
200
Accumulate Waste Water Stream in Settling Tank
210
Settle Solids in Settling Tank to form a Settled Sludge and Supernatant
220
231
Accumulate Settled Sludge and U.F. Sludge
Filter Supernatant via U.F. to form Filtrate and U.F. Sludge
241
232a
232
Send Sludge Supernatant to be accumulated in the Settling Tank.
Gravity Thicken Sludge to form Sludge Supernatant and Thickened Sludge
Filter Filtrate via R.O. to form the Permeate and Intermediate Concentrate
242
243
243a
Send Pressate to be accumulated in the Settling Tank
Dewater Thickened Sludge to form Thickened Solids and Pressate
Filter Intermediate Concentrate via R.O. to form Recirculation Permeate and Concentrate
Send Recirculation Permeate to be filtered by the U.F. System.
233a
233
250
Blend Concentrate and Thickened solids to form Slurry
Send Slurry to Anaerobic Digester
260

SYSTEM AND METHOD FOR SEPARATING NUTRIENTS FROM A WASTE STREAM

FIELD OF THE APPLICATION

Background

[0001] The present invention is directed to systems for treatment of waste water and more particularly, to systems for removing solids and solvated material from waste water. It is known that waste water, such as municipal waste water and process waste water resulting from agricultural, food and beverage processes, contains nutrients supporting biological growth. Nutrient examples include proteins, sugars, fats, oils, alcohol, phosphorous-containing compounds, and nitrogen-containing compounds. When discharged directly into the environment these compounds are considered pollutants that can lead to undesirable growth of pathogenic bacteria, eutrophication of watersheds, and other undesirable effects. Consequently, one common objective of waste water treatment is the removal or reduction of these nutrients to produce treated water that can safely be discharged into the environment.

[0002] Currently, the most common method for removal of nutrients from waste water involves the use of primary treatment systems to settle solids as sludge for disposal in landfills and secondary treatment systems using bacteria which consume the nutrients, thus removing them from the waste stream. While the bacteria are dense enough and large enough to settled or filtered from the waste stream, they present several challenges. It is difficult to timely monitor the health of the bacteria. Unanticipated changes in the composition of the waste stream can kill, sicken, or starve the bacteria. In addition, the settled or filtered bacteria create another solid to be disposed of, typically in a landfill.

[0003] A better solution for treatment of waste water is to extract the nutrients, permitting them to be re-purposed for other applications such as fertilizer or as feed-stock for anaerobic digester energy production.

[0004] The extraction of nutrients from waste water poses several challenges. The various materials comprising the nutrients present in waste water typically possess a broad range of physical and chemical properties such that there is no single method to efficiently extract them. By way of example, some materials, such as proteins, may be easily removed via coalescence and settling. Conversely, other compounds may be more effectively removed via microfiltration and ultrafiltration, and for very small molecules and ions such as sugars and aqueous salts nanofiltration and reverse osmosis systems are required. Each filtering technique has its own advantages and limitations. Microfiltration is typically effective for removal of particulate matter with a size range of about 0.1 μm to about 10 μm. Nanofiltration, ultrafiltration and reverse osmosis are all pressure-driven filtration processes requiring high pressure pumps, CIP (clean in place) subsystems, and pre-treatment of the influent, for example, to prevent filter membrane fouling.

[0005] Ultrafiltration is typically effective for removal of matter with a size range of about 0.005 μm to about 0.1 μm and nanofiltration is typically effective for removal of colloidal and dissolved matter down to about 0.001 μm. Reverse osmosis is used for even smaller particles and is typically effective for removal of dissolved matter down to sizes as low as 0.0001 μm.

[0006] The application of each of these types of filtration systems to typical industrial waste stream is complicated by the need to keep the filtration membranes from fouling by the relatively high concentrations of materials larger than their target exclusion size, e.g., fibers, hair, and various food and grain remnants.

[0007] A further challenge is that the nutrients are typically present in low concentrations creating a need to efficiently concentrate the nutrients for their re-purposing. By way of example, a typical waste stream from a brewery may have a total solids content of 1500 mg/l, with nitrogen concentration of about 30 mg/l to 100 mg/l and phosphorous content of about 30 mg/l to 100 mg/l.

[0008] What is needed is a system and method to extract and concentrate nutrients from waste water such that the nutrients can be efficiently and cost-effectively repurposed.

SUMMARY OF THE INVENTION

[0009] As disclosed in U.S. Pat. No. 7,972,505, "Primary Equalization Settling Tank"; U.S. Pat. No. 8,225,942, "Self-Cleaning Influent Feed System for a Waste Water Treatment Plant"; U.S. Pat. No. 8,398,864, "Screened Decanter Assembly"; U.S. Pat. No. 9,643,106 "Screen Decanter for Removing Solids from Wastewater"; U.S. Pat. No. 9,744,482, "Screen Decanter for Screening Solids from Waste Water"; U.S. Pat. No. 9,782,696, "Method for Maximizing Uniform Effluent Flow Through a Waste Water Treatment System; pending U.S. patent application Ser. No. 14/141,297, "Method and Apparatus for a Vertical Lift Decanter System in a Water Treatment Systems"; U.S. patent application Ser. No. 14/142,099, "Floatables and Scum Removal Apparatus"; U.S. patent application Ser. No. 14/325,421, "IFS and Grit Box for Water Clarification Systems"; and U.S. patent application Ser. No. 14/471,247 "Method and Apparatus for Using Air Scouring of a Screen in a Water Treatment Facility"; U.S. patent application Ser. No. 14/985,842, "System for Processing Wastewater" (hereinafter the '842 application); U.S. patent application Ser. No. 15/887,987 "Improved System and Method for Static Mixing in a EPT Using a Fluid Containment Assembly" (hereinafter the '087 application); the inventor has developed systems and processes for treatment of waste water. The above-named applications and patents are incorporated herein by reference in their entirety for all purposes.

[0010] A new improved apparatus and method to separate nutrients from a waste stream is now described. A system and method to separate and concentrate nutrients from process waste water comprising the steps of accumulating the process waste water in a settling tank; settling the solids to form a supernatant and settled sludge; filtering the supernatant with a filtration system to form a permeate and a concentrate; dewatering the settled sludge to form thickened solids and a pressate; and, blending the thickened solids and the concentrate to form a slurry.

[0011] Further features and advantages of the present invention will become apparent to those of ordinary skill in the art in view of the drawings and detailed description of preferred embodiments below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The features of the application can be better understood with reference to the drawings described below and to the claims. The drawings are not necessarily to scale,

emphasis instead generally being placed upon illustrating the principles described herein. In the drawings, like numerals are used to indicate like parts throughout the various views.

[0013] FIG. **1** provides a description of a system for extracting and concentrating nutrients from a waste stream in accordance with the instant application.

[0014] FIG. **2** provides an overview of an influent delivery system and a settling tank as disclosed in the '987 application.

[0015] FIG. **3** provides an isometric view of decanter assembly **1400**, as further disclosed in the '842 application.

[0016] FIG. **4** provides a second isometric view of decanter assembly **1400**, as further disclosed in the '842 application.

[0017] FIG. **5** provides a flow chart of a method for extracting and concentrating nutrients from a waste stream in accordance with the instant application.

[0018] FIG. **6** provides a description of an alternate embodiment of a system for extracting nutrients from a waste stream in accordance with the instant application.

[0019] FIG. **7** provides a description of a sludge tank used to thicken solids in accordance with the instant application.

[0020] FIG. **8** provides a description of a representative ultrafiltration system in accordance with the instant application.

[0021] FIG. **9** provides a flow chart of a preferred embodiment for extracting nutrients from a waste stream in accordance with the instant application.

DETAILED DESCRIPTION OF THE INVENTION

[0022] With reference to FIG. **1**, in a preferred embodiment of the instant application, a system **10** for extracting nutrients from process waste water comprises a settling tank **130** to accumulate process waste water **22** from a plant **100**.

[0023] In a currently preferred embodiment, settling tank **130** is substantially similar to the settling tank disclosed in the '087 application. With reference to FIG. **2**, and as disclosed in more detail in the '987 application, in a preferred embodiment, settling tank **130** comprises a tank **12** provided with a sludge hopper **14** in a bottom portion **16** of tank **12** (not to scale). The sludge hopper **14** comprises an upper portion **17** and a lower portion **18** separated by a scouring plate **56**. Sludge hopper **14** further comprises a bottom opening **30'**, drain **31'**, and drain valve **70**.

[0024] A decanter assembly **1400** is provided within the clarification tank **12**. Preferably, decanter assembly **1400** is substantially similar to the exemplary decanter assembly of the '842 application as shown in FIG. **3** and FIG. **4**. Decanter assembly **1400** comprises a platform **1420** including a drain manifold **1430** having a central drain opening **1440**. Three decanter frames **1460** are mounted to platform **1420**. Each decanter frame **1460** includes a perforated central standpipe **1470** that extends through an opening in the lower portion of the decanter frame **1460** to connect to drain manifold **1430**. Each frame **1460** is surrounded by a cylindrical screen **1500** connected to frame **1460** such as by screws **1520** in such a fashion that all influent flow entering frames **1460** must pass through a screen **1500**. Preferably, screens **1500** have a porosity in the range of 25-75 micrometers, and most preferably about 50 micrometers.

[0025] With reference to FIG. **2**, drain manifold **1430** (FIG. **4**) is in fluid communication with effluent hose **84**, which in turn is in fluid communication with effluent pipe **86** to decant screened waste water **87** that passes through the decanter frames **1460**, drain manifold **1430**, and effluent pipe **86**. The decanter assembly **1400** is at an elevation higher than the sludge hopper **14** and is raised and lowered via vertical lift mechanism **85** to follow vertical changes in the upper surface of waste water within the tank **12**. Influent waste water **24'** is delivered to settling tank **130** via waste water influent pipe **20'**.

[0026] Referring again to FIG. **1**, settling tank **130** is in fluid communication with filtration system **141** and arranged to deliver the supernatant **23** resulting from settling solids out of the process waste water **22**. Settling tank **130** is additionally in fluid communication with dewatering system **181** and arranged to deliver the sludge **31** resulting from settling solids from the process waste water **22** in settling tank **130** to dewatering system **181**. In a preferred embodiment, as described in more detail hereinafter, dewatering system **181** further comprises a gravity thickening tank to first gravity-thicken the sludge and a belt filter press to dewater the gravity-thickened sludge. Other apparatus may be used to dewater and/or thicken the sludge **31**, including without limitation a centrifuge, rotary press, screw press and filter press as dictated by the needs of the application.

[0027] Filtration system **141** is in fluid communication with blender **190** and arranged to deliver the filtration system reject, or concentrate, from filtration of supernatant **23** to blender **190**. Filtration system **141** permeate **25** is discharged from system **10** as finished water. Filtration system **141** may comprise without limitation a micro-filtration system, ultra-filtration system, nanofiltration system and reverse-osmosis system or some combination thereof as dictated by the requirements of the application.

[0028] Blender **190** is in fluid communication with dewatering system **181** to receive thickened solids **35** and in fluid communication with filtration system **141** to receive concentrate **44**. Blender **190** blends the thickened solids **35** and concentrate **44** to form slurry **36**. In a preferred embodiment, slurry **36** is delivered to anaerobic digester **300**.

[0029] In operation, and with reference to FIG. **5**, in step **210** process waste water from a food processing application is accumulated in a settling tank. The process waste water is rich in nutrients, commonly measured in terms of biological oxygen demand or BOD. Note: "Biological Oxygen Demand" (BOD), also known as Biochemical Oxygen Demand, is the amount of oxygen needed by aerobic microorganisms to decompose all the digestible organic matter in a sample of water; it is used in the eco-sciences as a measure of organic pollution. As used herein, the term "BOD" also means more generally the unit volume load, both dissolved and suspended, of such organic material in waste water.

[0030] The nutrients may be dissolved in the process waste water or may be particulate. The total amount of particulate matter in the process waste water is commonly referred to as Total Suspended Solids (TSS). TTS is a water quality measurement which, as used herein, is expressed as the unit volume load of suspended solids, both organic and inorganic, in water. It is listed as a conventional pollutant in the U.S. Clean Water Act.

[0031] After accumulating the process waste water in the settling tank, and with reference to step **220**, solids settle to the bottom of the settling tank during a "settle time" resulting in the formation of a separated sludge and supernatant. Both the sludge and the supernatant may contain significant

nutrients that can be used, as for instance in an anaerobic digester to produce methane. Generally, the supernatant will have a relatively greater concentration of nutrients dissolved in the fluid and relatively lesser concentration as suspended particles when compared to the sludge.

[0032] In a preferred embodiment using the settling tank **130** (reference FIG. **2**) disclosed in the '987 application, more than 90% of particulate matter is efficiently extracted from the process waste water to form a sludge high in BOD and phosphorous. Preferably, the supernatant of step **220** is decanted from preferable settling tank **130** via a decanter assembly **1400** substantially similar to the exemplary decanter assembly of the '842 application as described elsewhere in this instant application with reference to FIG. **3** and FIG. **4** to remove residual particulate matter larger than the pore size of screens **1500**. It is further preferable that screen **1500** have a pore size in the range of 25-75 micrometers, and most preferably about 50 micrometers. In this preferred embodiment, the supernatant decanted via decanter assembly **1400** to produce screened waste water **87** (FIG. **2**.) corresponds to supernatant **23** of FIG. **1**. Other important nutrients such as sugars, alcohols, fatty acids, NPN (non-protein nitrogen), and other organic compounds will predominantly remain solvated or suspended in the supernatant. To extract and concentrate the nutrients from the sludge and the supernatant, distinct process steps are used.

[0033] With reference to step **230**, the sludge is dewatered to concentrate the nutrients found in the sludge, producing thickened solids, preferably thickened solids with 25%-40% total solids by weight. Thickened solids with a high concentration of total solids can be difficult to efficiently transport, e.g., using pumps.

[0034] With reference to step **240**, the supernatant is filtered to form a permeate and a concentrate. In a typical water reuse application, the supernatant is highly filtered to permit discharge of the resulting permeate to reduce measured amounts of BOD, TSS, nitrogen-compounds, and other components to very low levels as required for discharge to municipalities, fields, streams, and the like. Consequently, high concentrations of supernatant nutrients are found in the filtration system concentrate.

[0035] With reference to step **250**, to facilitate transport of the thickened solids, such as via pumps, and to create a more nutrient rich product, the thickened solids are blended with the concentrate to form a slurry, and in step **260** the slurry is sent to an anaerobic digester.

[0036] With reference to FIG. **6**, in a second preferred embodiment of the instant application, a system **11** for extracting nutrients from process waste water comprises equalization tank **110** for receiving process waste water **20** discharged from plant **100**. Equalization tanks for accumulating and potentially pre-treating process waste water are well known in the art. An influent delivery system **120** is in fluid communication with equalization tank **110** and settling tank **130** to transfer process waste water **21** from equalization tank **110** to settling tank **130**. Optionally, influent delivery system **120** further comprises means for addition of coagulants and/or flocculants to enhance coalescence and settling of solids in the settling tank **130**. In a currently preferred embodiment, influent delivery system **120** is substantially similar to the influent delivery system disclosed in the '987 application.

[0037] With reference to FIG. **2**, and as described in more detail in the '987 application, in a currently preferred embodiment influent delivery system **120** comprises pump **21'** controlled by flow control apparatus **23'** which may include a flow meter, variable frequency drive, and control valving (not shown) in known fashion. Further, dosing apparatus **25'** may be provided for, e.g., adjusting pH of the influent or adding coagulants and/or flocculants thereto. In a currently preferred embodiment, influent pipe **20'** further includes an inline static mixer **40'**, such as for example a helical auger, arranged to provide mixing of coagulants and/or flocculants with the influent stream.

[0038] Continuing with FIG. **6**, settling tank **130** is in fluid communication with ultrafiltration (UF) system **140** and arranged to transfer the supernatant **23** resulting from settling solids out of the process waste water **22**. Settling tank **130** is additionally in fluid communication with and arranged to transfer to sludge tank **170** the sludge **31** resulting from settling solids from the process waste water **22** in settling tank **130**.

[0039] Referring now to FIG. **7**, in a currently preferred embodiment, sludge tank **170** comprises a sludge settling tank **171**, sludge drain **172**, and valve **173** to control discharge of gravity-thickened sludge **34** through sludge drain **172**. Sludge tank **170** further comprises pump **177** to discharge sludge supernatant **42** via discharge pipe **176**. Sludge tank **170** receives settling tank sludge **31** via intake pipe **178** and, as described in more detail henceforth, ultrafiltration sludge **32** via intake pipe **179**.

[0040] Referring again to FIG. **6**, ultrafiltration system **140** is in fluid communication with reverse osmosis (RO) system **150** and arranged to transfer the UF (ultrafiltration) filtrate **24** to RO system **150** for filtration.

[0041] Ultrafiltration system **140** is in fluid communication with sludge tank **170** and arranged to transfer UF sludge **32** resulting from concentration of materials filtered out of the supernatant **23** to sludge tank **170**.

[0042] With reference to FIG. **8**, in a currently preferred embodiment of the instant application, ultrafiltration system **140** comprises a feed tank **142** arranged to receive supernatant **23** via inlet pipe **149** for filtration by filter membranes **144**. Feed tank **142** holds fluid **143** comprising supernatant **23** and materials that do not pass through the filter membranes **144** (the "reject"). In a preferred embodiment, filtration membrane **144** is a hollow fiber membrane with the fluid to be filtered passing through the outside of the fiber to the inner portion of the membrane. Filtration pump **146***b* creates a negative pressure to draw filtered fluid through the filter membrane **144** and connecting hose **146** for discharge as ultrafiltration filtrate **24** via discharge pipe **146***c*.

[0043] Sensor **145***a* and controller **145***b* are arranged to measure the concentration of rejected materials in fluid **143**. During operation, the concentration of the reject will increase to a level that the efficacy of the ultrafiltration system is negatively impacted (e.g., membrane **144** may foul, throughput is reduced). When the reject concentration exceeds that level, the fluid **143** is discharged from tank **142** as ultrafiltration sludge **32** via discharge pump **147***b* and discharge pipes **147***a* and **147***c*. In a currently preferred embodiment, sensor **145***a* comprises a total suspended solids sensor. In alternative embodiments, sensor **145***a* may comprise a pH sensor, conductivity sensor, or turbidity sensor as dictated by the needs of the application.

[0044] Reverse osmosis system **150** is in fluid communication with reverse osmosis concentrate recovery system **160**, a second reverse osmosis system. Reverse osmosis system **150** delivers the reject, or intermediate concentrate **33**, from filtration of UF filtrate **24** for filtration by reverse osmosis concentrate recovery system **160**. Reverse osmosis system **150** permeate **25** is discharged from system **10** as finished water.

[0045] Sludge tank **170** is in fluid communication with belt filter press **180** and delivers gravity-thickened sludge **34** to the belt press **180**. Sludge tank **170** is further in fluid communication with EQ tank **110** and delivers supernatant **42** to EQ tank **110** as described herein with respect to FIG. **7**.

[0046] Belt filter press **180** dewaters gravity-thickened sludge **34** to produce a pressate **41** and thickened solids **35**. Belt filter press **180** is in fluid communication with blender **190** and delivers thickened solids **35** to blender **190**. Belt filter press **180** is further in fluid communication with EQ tank **110** and delivers pressate **41** to EQ tank **110**. Belt filter presses to dewater sludge are well known in the art. Alternatively, dewatering and/or thickening of any of sludge **31**, ultrafiltration sludge **32**, and gravity thickened sludge **34**, may be accomplished by other apparatus, including without limitation, a centrifuge, rotary press, filter press, and screw press as dictated by the needs of the application.

[0047] Blender **190** is in fluid communication with RO concentration recovery **160** to receive concentrate **44**. Blender **190** operates to macerate the thickened solids **35** and blend them with concentrate **44** to form a slurry **36**. In a currently preferred embodiment, blender **190** is in fluid communication with a pump **195** that transfers slurry **36** to anaerobic digester **300**.

[0048] In operation, and with reference to FIG. **6** and FIG. **9**, in a currently preferred embodiment in step **200** a coagulant is added to the waste stream prior to step **210** wherein the waste stream **22** is accumulated in settling tank **130**. Preferably, the coagulant comprises aluminum chlorohydrate, such as Kemira PAX-XL 1900 manufactured by Kemira Oyj. In a representative example, a waste stream comprising organic materials from food and beverage processing with total suspended solids of 75 mg/l to 5,000 mg/l and BOD between about 300 mg/L and 15,000 mg/L or more, coagulant Kemira PAX-XL 1900 is added to the waste stream at the rate of 100 mg to 800 mg per liter of waste water. Note that for purposes of the instant application, coagulant is meant to include compounds used to enhance coalescence of solids, including without limitation materials commonly referred to as flocculants. Further, the coagulant may comprise ferric chloride or other compounds including without limitation anionic and cationic polymers as the requirements of the application dictate.

[0049] In a currently preferred embodiment, the coagulant is added to the influent stream via dosing apparatus **25'** (Reference FIG. **2**) and dispersed via static mixer **40'**.

[0050] After accumulating the process waste water in the settling tank, and with reference to step **220**, solids settle to the bottom of the settling tank during a "settle time" resulting in the formation of a sludge and a supernatant. Both the sludge and the supernatant may contain significant nutrients that can be used, as for instance in an anaerobic digester, to produce methane. Generally, the supernatant will have a relatively greater concentration of nutrients dissolved in the fluid and a relatively lesser concentration of suspended particles when compared to the sludge.

[0051] In a preferred embodiment using the settling tank **130** (reference FIG. **2**) disclosed in the '987 application, more than 90% of particulate matter is efficiently extracted from the process waste water to form a sludge high in BOD and phosphorous. Preferably, the supernatant of step **220** is decanted from preferable settling tank **130** via a decanter assembly **1400** to remove residual particulate matter larger than the pore size of screens **1500** as described elsewhere in this instant application with reference to FIG. **3** and FIG. **4**. It is further preferable that screens **1500** have a pore size in the range of 25-75 micrometers, and most preferably about 50 micrometers. Removal of particulates from the supernatant via screens **1500** reduces the likelihood and frequency of membrane fouling in subsequent filtration steps, thereby increasing the life of the filtration systems and improving their throughput by reducing the frequency of backwash and CIP cycles; e.g., the UF system membranes of step **241**. In this preferred embodiment, the supernatant decanted via decanter assembly **1400** to produce screened waste water **87** (FIG. **2**.) corresponds to supernatant **23** of FIG. **1** and FIG. **6**. Important nutrients such as sugars, alcohols, fatty acids, NPN (non-protein nitrogen), and other organic compounds will predominantly remain solvated or suspended in the supernatant. To extract and concentrate the nutrients from the sludge and the supernatant distinct further process steps are used.

[0052] In step **241**, the supernatant **23** from step **200** is filtered via an ultrafiltration system **140** to form an ultrafiltration filtrate and a UF sludge. As disclosed elsewhere in this application with respect to FIG. **8**, when the concentration of the rejected materials in the feed tank **142** exceeds a threshold level, ultrafiltration sludge **32**, containing valuable nutrients, is discharged from the ultrafiltration system **140** to sludge tank **170**.

[0053] In step **242**, ultrafiltration filtrate is filtered by reverse osmosis system **150**. As is well known in the art, in operation a reverse osmosis system passes a fraction of the incoming water through the reverse osmosis membranes to produce a permeate with a lower concentration of dissolved materials relative to the incoming fluid and rejects a fraction of the incoming water to produce a concentrate with a higher concentration of dissolved materials relative to the incoming fluid. The permeate **25** discharged by system **11** as finished water. However, the concentrate from reverse osmosis system **150**, hereinafter referred to as "intermediate concentrate" **33**, has valuable nutrients that can be extracted.

[0054] When extracting nutrients from a waste stream it is desirable to concentrate them, minimizing the volume of liquid to be handled while returning the greatest possible fraction of clean water for reuse. The intermediate concentrate **33** nutrient concentration is relatively low. To further concentrate the nutrients, in step **243**, the intermediate concentrate is filtered by reverse osmosis concentrate recovery system **160** to form recirculation permeate **43** and concentrate **44**. In a currently preferred embodiment, the concentrate **44** nutrient concentration is increased by a factor of about 3 when compared to the intermediate concentrate nutrient concentration. To extract the greatest fraction of clean water from the system **11** the recirculation permeate **43** is delivered to the ultrafiltration system **140**. The concentrate **44** is delivered to blender **190** as described in more detail elsewhere in the instant application.

[0055] Returning to step **220**, settled sludge **31** is discharged from settling tank **130** to sludge tank **170**. In step **231**, settled sludge **31** and UF sludge **32** are accumulated in sludge tank **170**. The accumulated sludge is thickened via settling of suspended particulates (gravity thickening) to form sludge supernatant **42** and a thickened sludge **34** (reference FIG. **7**) that further concentrates nutrients and other valuable organic and inorganic matter that is primarily in particulate form. The sludge may be allowed to settle for hours or days depending upon the settling rates of the particulates, size of the sludge tank, and desired thickening. The sludge supernatant **42** is delivered to the equalization tank **110** to recapture the water for reuse. In a current embodiment, the sludge supernatant **42** is pumped to the equalization tank **110**, although other mechanisms for delivery may be suitable based on the needs of the application, including by way of example and not limitation, gravity feed.

[0056] After desired gravity thickening has occurred, thickened sludge **42** is dewatered to form thickened solids **23** and pressate **41**. In a currently preferred embodiment, thickened sludge **34** is dewatered with belt filter press **180**. The pressate **41** is delivered to the equalization tank **110** to recapture the water for reuse. In a current embodiment, the pressate **41** is pumped to the equalization tank **110**, although other mechanisms for delivery may be suitable based on the needs of the application, including by way of example and not limitation, gravity feed.

[0057] Belt filter presses to dewater sludge are well known in the art. Alternatively, dewatering of gravity thickened sludge **34** may be accomplished by other apparatus, including without limitation, a centrifuge, rotary press, filter press, and screw press as dictated by the needs of the application.

[0058] In a current embodiment, the thickened sludge **34** contains about 1%-3% solids by weight prior to dewatering in step **233**, whereas the thickened solids after dewatering are about 25%-40% solids by weight. While the thickened solids are desirably concentrated, the high-solids content presents a challenge for transport of the solids away from system **11** via traditional slurry or positive displacement pumps. Additionally, there are valuable nutrients in the concentrate **44** that are preferably recovered. To simplify transport of the nutrients and solid matter in step **250** and produce a single material containing the extracted nutrients, the thickened solids **35** are blended by a blender **190** with the concentrate **44** to form a slurry **36**. Blenders are well known in the art. By way of example and not limitation, in a current embodiment, the blender comprises a XRipper XRL Food Waste Grinder manufactured by Vogelsang. Alternative blenders, including macerators, grinders, and the like may be used as dictated by the needs of the application. In a current embodiment, the slurry **36** is pumped via positive displacement pumps **195** to an anaerobic digester. However, the slurry **36** may easily be transported via other means including without limitation, gravity, screw conveyer, bucket elevator, and the like as dictated by the needs of the application. Similarly, the slurry may be transported to trucks for hauling, agricultural fields for application, or other post-processing steps as dictated by the requirements of the application.

What is claimed is:

1. A method to separate nutrients from a waste stream comprising the steps of:

a) accumulating said waste stream in a settling tank;

b) settling solids in said settling tank to form a supernatant and a settled sludge;

c) filtering the supernatant with a filtration system to form a first permeate and a first concentrate;

d) dewatering said settled sludge to form thickened solids and a pressate; and

e) blending said thickened solids and said concentrate to form a slurry.

2. The method of claim **1** further comprising the step of delivering said slurry to an anaerobic digester.

3. The method of claim **1** further comprising the step of adding a coagulant to said waste stream prior to said step of settling solids in said settling tank.

4. The method of claim **1** wherein, the said step of dewatering said settled sludge further comprises gravity thickening of said settle sludge to form a sludge supernatant and a thickened sludge.

5. The method of claim **4**, further comprising the step of accumulating said sludge supernatant in said settling tank.

6. The method of claim **1** wherein, the step of dewatering said settled sludge comprises using apparatus selected from the group consisting of: a belt filter press, a centrifuge, a rotary press, a screw press, and a plate filter press.

7. The method of claim **1** wherein the step of filtering said supernatant comprises filtering with a filtration system selected from the group consisting of micro-filtration, ultra-filtration, nano-filtration, and reverse osmosis.

8. The method of claim **1**, wherein the step of filtering said supernatant with a filtration system comprises the steps of:

a) filtering said supernatant with an ultrafiltration system to form an ultrafiltration sludge and an ultrafiltration filtrate; and,

b) filtering said ultrafiltration filtrate with a reverse osmosis system to form said first permeate and said first concentrate.

9. The method of claim **8** further comprising the step of dewatering said ultrafiltration sludge.

10. The method of claim **8** wherein filtering said filtrate with a reverse osmosis system further comprises the steps of:

a) filtering said filtrate with a first reverse osmosis component to form said first permeate and a second concentrate;

b) filtering said second concentrate with a second reverse osmosis component to form said first concentrate and a second permeate.

11. The method of claim **9** further comprising the step of accumulating said pressate in said settling tank.

12. A method to separate nutrients from a waste stream comprising the steps of:

a) accumulating said waste stream in a settling tank;

b) settling solids in said settling tank to form a settled sludge and a supernatant;

c) filtering said supernatant with an ultrafiltration system to form an ultrafiltration sludge and a filtrate;

d) filtering said filtrate with a reverse osmosis system to form a first permeate and a first concentrate,

e) dewatering said settled sludge to form thickened solids and a pressate;

f) blending said thickened solids and the first concentrate to form a slurry.

13. The method of claim **12** further comprising delivering said slurry to an anaerobic digester.

14. The method of claim **12** further comprising adding a coagulant to said waste stream prior to the step of settling solids in said settling tank.

15. The method of claim **12** further comprising the steps of:

a) dewatering said settled sludge by gravity thickening to form a sludge supernatant and a thickened sludge;

b) dewatering said thickened sludge to form said thickened solids and said pressate.

16. The method of claim **15** further comprising the step of accumulating said sludge supernatant in said settling tank.

17. The method of claim **12** further comprising the steps of:

a) accumulating said waste stream in an equalization tank before said step of accumulating said waste stream in a settling tank; and,

b) discharging said waste stream to said settling tank.

18. The method of claim **17** further comprising the step of accumulating pressate in said equalization tank.

19. The method of claim **12** wherein filtering said filtrate with a reverse osmosis system further comprises the steps of:

a) filtering said filtrate with a first reverse osmosis component to form said first permeate and a second concentrate;

b) filtering said second concentrate with a second reverse osmosis component to form said first concentrate and a second permeate.

20. The method of claim **18** further comprising the step of filtering said second permeate with said ultrafiltration system.

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