

An Apparatus and Method for Treating Water for Rearing Aquatic BeingsField of the invention

- 5 The present invention relates to an apparatus and method for treating water for rearing aquatic beings. The water is held in a holding space, for example, a pond such as an outdoor pond or an indoor recirculating system.

Background of the Invention

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Oxygen is an important parameter of water quality for pet fish hobby, large scale fish pond farming, as well as fish cultivation. Low dissolved oxygen (DO) levels and the presence of potential pond pollutants are amongst reasons contributing to poor health of fishes, a low growth rate of fishes, a low reproduction rate of fishes and excessive
15 fish losses.

Other than oxygen, ozone is another factor that affects the results of fish farming and fish cultivation. Providing ozone to the water helps to enhance the water quality. In particular, ozone serves as a disinfectant for killing harmful bacteria within the water
20 and helps to increase the DO level in the water.

Oxygen system components and ozone system components are available in the current market. These components are generally used separately, with the oxygen system components dosing oxygen directly into the water and the ozone system
25 components dosing ozone directly into the water. Settings on these components have to be manually adjusted to change the amount of oxygen and the amount of ozone dosed into the water. Thus, when using these components, a user has to periodically monitor the Oxidation Redox Potential (ORP) in the water and manually adjust the settings on the components when necessary. Any lapse in the monitoring can cause
30 over-dosing of oxygen and/or ozone, and this may be fatal for the fishes in the water.

Summary of the invention

The present invention aims to provide a new and useful apparatus and method for treating water for rearing aquatic beings, wherein the water is held in a holding space.

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In general terms, the present invention proposes continuously monitoring the Oxidation-Reduction Potential (ORP) of the water in the holding space and controlling the provision of ozone to the water based on the ORP using a control unit.

10 Specifically, a first aspect of the present invention is an apparatus for treating water for rearing aquatic beings, wherein the water is held in a holding space and wherein the apparatus comprises:

a sensing element configured to determine an Oxidation-Reduction Potential (ORP) of the water in the holding space;

15 a mixing unit configured to receive water from the holding space, oxygen and ozone and further configured to facilitate mixture of the water with the oxygen and the ozone; and

a control unit configured to control provision of the ozone to the mixing unit based on the determined ORP.

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Such an apparatus allows automatic control of the provision of ozone to the water (the term "automatic" is used herein to mean that, although human interaction may be required to start the apparatus, human interaction is not required while the apparatus is used to control the provision of ozone. There may however still be human interaction during the operation of the apparatus to, for example, adjust the settings on the apparatus). Thus, with such an apparatus, it is not necessary for a user to constantly monitor the ORP of the water to adjust the amount of ozone to provide. This apparatus can thus help lower the risks of over-dosing or under-dosing of the ozone in the water, in turn achieving better aquaculture ozonized water treatment. Further, using a mixing unit to mix the water from the holding space with oxygen and ozone, and thereafter providing the treated water back to the holding space achieves better treatment of the

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water as compared to dosing oxygen and ozone separately and directly into the holding space.

5 The control unit may be configured to start providing ozone to the mixing unit if the ORP is equal to or below a lower limit and further configured to stop said provision of the ozone to the mixing unit when the ORP reaches equal to or above an upper limit. This is advantageous over using a single limit. This is because when the ORP falls to or below the lower limit, a sufficient (and yet, not too high) amount of ozone can be provided to the water so that the ORP can be maintained above the lower limit for a longer period of time. This reduces the frequency at which the ozone generator has to be switched and in turn helps increase the lifespan of the ozone generator, and hence the apparatus.

15 The control unit may further comprise an oxygen concentrator configured to generate the oxygen; and an ozone generator configured to generate the ozone. This helps to reduce the space required for the operation of the apparatus, and improves the ease of setup and deployment of the apparatus.

20 The ozone generator may be configured to generate ozone using the oxygen generated by the oxygen concentrator. This increases the efficiency of ozone generation for the same energy input.

25 The control unit may further comprise a perforated tray configured to hold the ozone generator. The perforations of the tray allow for better air-flow within the control unit and increases the rate at which the hot air built up within the control unit can be sucked out of the control unit.

The oxygen may be continuously provided to the mixing unit. This increases the amount of dissolved oxygen in the water.

30 The mixing unit may comprise a plurality of oxidizing columns configured to simultaneously receive water from the holding space and further configured to facilitate

the mixture of the received water with the oxygen and the ozone. This helps to increase the efficiency of treating the water so the same volume of water can be treated in a shorter amount of time. For example, the mixing unit may comprise two oxidizing columns. Having two oxidizing columns can help treat the same volume of water in a shorter amount of time as compared to having a single oxidizing column, but does not require as much space as having three or more oxidizing columns, thus reducing the size of the apparatus.

The mixing unit may comprise a tube configured to allow water to flow through; and a plurality of skewed plates arranged to impact on the water flowing through the tube. This creates a bubbling effect in the water received by the mixing unit so as to facilitate the mixture of gasses into the water. For example, the plurality of skewed plates may be arranged to form a vertical spiral structure along the center of the tube.

The water may be urged through the mixing unit in an urging direction and the apparatus may further comprise non-return valves configured to prevent flow of the water opposite to the urging direction. This helps increase the efficiency of water treatment by the apparatus. This can also prevent damage of the internal components of the apparatus.

The apparatus may comprise a casing formed of stainless steel. This helps to prevent corrosion of the apparatus over time and provides sufficient structural strength to the apparatus to prevent toppling of the apparatus. These in turn help the apparatus to withstand constant weather changes and different weather conditions.

The apparatus may further comprise a communication unit configured to communicate wirelessly with a monitoring unit. This allows data determined by the apparatus (e.g. the ORP of the water in the holding space, the oxygen level of the water in the holding space, the temperature of the apparatus etc.) to be communicated wirelessly to the monitoring unit, thereby allowing remote monitoring of the apparatus and the water in the holding space.

A second aspect of the present invention is a method for treating water for rearing aquatic beings, wherein the water is held in a holding space and wherein the method comprises repeatedly performing the following steps:

urging the water from the holding space through a mixing unit;

5 providing the mixing unit with oxygen for mixing with the water;

determining an Oxidation-Reduction Potential (ORP) of the water in the holding space; and

controlling provision of ozone to the mixing unit for mixing with the water, wherein the controlling is based on the determined ORP and is performed using a control unit.

The advantages of this method are similar to those of the apparatus in the first aspect.

Using the control unit may comprise configuring the control unit to start providing ozone to the mixing unit if the ORP is below or equal to a lower limit and to stop said provision of the ozone to the mixing unit when the ORP reaches above or equal to an upper limit.

Further, the method may comprise setting a set-point for the ORP of the water in the holding space; and calculating the lower limit and the upper limit based on the set-point using the control unit. Allowing the user to set only one set-point instead of both the lower and upper limits helps increase convenience to the user.

Brief Description of the Figures

Embodiments of the invention will now be illustrated for the sake of example only with reference to the following drawings, in which:

Fig. 1 shows a top view of an apparatus for treating water according to an embodiment of the present invention;

30 Fig. 2 shows the apparatus of Fig. 1 with its doors in an opened position;

Figs. 3(a) – (b) respectively show side and front views of the apparatus of Fig. 1 as seen from A1, B1 indicated in Figs. 1 and 2;

Figs. 4(a) – (b) respectively show side and rear views of the apparatus of Fig. 1 as seen from C1 and D indicated in Figs. 1 and 2;

Figs. 5(a) – (c) respectively show interior views of a control unit of the apparatus of Fig. 1 as seen from A3, B3 and C3 indicated in Fig. 2;

5 Figs. 6(a) – (b) respectively show a front view and a side view of an oxidizing unit of the apparatus of Fig. 1;

Fig. 7 shows the oxidizing unit of the apparatus of Fig. 1 when the apparatus of Fig. 1 is in use; and

10 Fig. 8 shows a method for controlling the provision of ozone to the oxidizing unit according to an embodiment of the present invention.

Detailed Description of the Embodiments

15 Fig. 1 shows an apparatus 100 for treating water according to an embodiment of the present invention. The water is for rearing aquatic beings and is held in a holding space. For example, the holding space may be an indoor or outdoor pond and the water may be for rearing fishes. The apparatus 100 may be referred to as an “Aquaculture Skid System” or in short, a “Skid”.

20 As shown in Fig. 1, the apparatus 100 comprises an oxidizing unit 102 configured to facilitate the dosing of the water with oxygen and ozone, and a control unit 104 configured to control this dosing.

25 The control unit 104 comprises a casing 106 formed of high grade stainless steel (SS 306). This allows the casing 106 to withstand corrosion and to be of a sufficiently strong structure to prevent toppling of the apparatus 100. These in turn allow the apparatus 100 to be deployed in the open with constant weather changes and in various locations with different weather conditions.

30 The control unit 104 further comprises a front door 202a, a first side door 202b and a second side door 202c connected to the casing 106. The doors 202a, 202b, 202c are movable between an opened position to allow access to the interior of the control unit

104 and a closed position to prevent access to the interior of the control unit 104 and to protect the interior of the control unit 104 from external elements such as rain. Fig. 2 shows the apparatus 100 with these doors 202a, 202b, 202c in the opened position.

5 Figs 3(a), 3(b), 4(a) and 4(b) respectively show side views of the apparatus 100 as seen from A1, B1, C1 and D indicated in Figs. 1 and 2. As shown in Figs 3(a), 3(b), 4(a) and 4(b), the doors 202a, 202b, 202c each comprises a handle and a lock configured to restrict access to the interior of the control unit 104.

10 In the opened position, the first and second side doors 202b, 202c allow access to the interior of the control unit 104 for the maintenance and servicing of the control unit 104, for example, for the replacement of parts. These doors 202b, 202c have a size that is sufficiently large to allow the maintenance and service personnel to safely access the interior of the control unit 104.

15 In the opened position, the front door 202a allows access to a front panel 302 of the control unit 104. The front panel 302 comprises a LCD display unit 304 and a plurality of control switches, such as control knob 310 shown in Fig. 3(b). The control switches comprise control knobs for setting and adjusting the amount of ozone and the amount
20 of oxygen to provide. The front panel 302 further comprises flowmeters, such as flowmeter 308 shown in Fig. 3(b). These flowmeters are for adjusting and setting the flow rate of the oxygen through the oxidizing unit 102, thereby adjusting the oxygen concentration of the water. An Oxidation-Reduction (Redox) Potential (ORP) transmitter 306 in the form of a Horiba transmitter HO480 is included in the control unit
25 104 and the front panel 302 is arranged with this transmitter 306 so that the front of the ORP transmitter 306 is visible to the user. This allows the user to set a set-point for the ORP of the water in the holding space on the ORP transmitter 306. The front door 202a comprises a clear panel to allow monitoring, via the LCD display unit 304, whether the cells of the ozone generator have deteriorated (and hence require
30 servicing). This clear panel also allows the viewing of the control knobs' and the ORP transmitter's 306 settings. Although not shown in the figures, the control unit 104 also comprises a temperature sensor for sensing the temperature of the apparatus 100.

The LCD screen is configured to display this temperature and a warning when this temperature is approaching an undesirable point that will affect the operation of the apparatus 100. In one example, at 48°C, a dialog box indicating that the apparatus 100 is warming up is shown on the LCD display unit 304 (together with the sounding of an alarm) and if no action is taken, the dialog box reappears when the temperature of the apparatus 100 reaches 49 °C. If there is still no action taken, the apparatus 100 will automatically shut down when its temperature (as detected by the temperature sensor) reaches 50.1°C. As mentioned above, the front door 202a comprises a lock for restricting access to the interior of the control unit 104 and this serves to prevent the mishandling and tempering of the control switches and the ORP transmitter 306.

Figs. 5(a) – (c) respectively show the interior of the control unit 104 as seen from A3, B3 and C3 indicated in Fig. 2. The control unit 104 comprises bottom and top drawer trays 502, 504 connected to the casing 106. The bottom drawer tray 502 is configured to hold an oxygen concentrator (not shown in the figures) for generating oxygen. The top drawer tray 504 is configured to hold an ozone generator (also not shown in the figures) for generating ozone and is perforated to improve air-flow within the control unit 104 and to increase the rate at which hot air built up within the control unit 104 can be sucked out of the control unit 104. The door 202c comprises an acrylic cover extending from the position of the top drawer tray 504 to the top of the ceiling of the casing 106. Small exhaust fans for the ozone generator are provided and these small exhaust fans are configured to urge air towards the door 202c to cool the ozone generator. The door 202c also comprises a large exhaust fan to suck out the hot air from the interior of the control unit 104, so as to direct the hot air to the exterior of the control unit 104.

Plates 506 are further included to shield the operator or user from the ozone generator when any of the doors 202a – 202c are in the opened position. Similar to the casing 106, the drawer trays 502, 504 are made of high grade stainless steel (SS 306). These trays 502, 504 are slidable to facilitate movement of the oxygen concentrator and the ozone generator to positions which allow easier maintenance and inspection of the oxygen concentrator and ozone generator.

The oxygen concentrator is configured to generate a continuous supply of high purity oxygen and in the apparatus 100, it is capable of doing so at a rate ranging from 1 to 10 litres per minute. The ozone generator is configured to generate ozone using the oxygen generated by the oxygen concentrator. In particular, the ozone generator
5 comprises a plurality of air cooled ozone cells with these cells housed on the top perforated drawer tray 504. An outlet tubing of the oxygen concentrator is connected to an inlet of the ozone generator comprising the ozone cells. Oxygen generated by the oxygen concentrator flows through this outlet tubing to the ozone generator. The ozone generator is configured such that it is controlled by a microcontroller and produces a
10 high concentration of ozone using a high frequency discharge operation. In the apparatus 100, the ozone generator is capable of generating ozone at a rate of 20 to 30 grams per hour.

The control unit 104 further includes a micro-switch which when opened, switches off
15 the ozone generator, thereby stopping the production of ozone. This micro-switch is attached to the door frame of the side door 202b such that the opening of the door 202b opens the micro-switch and stops the production of ozone.

The control unit 104 also comprises a printed circuit board, various electrical
20 components, mechanical parts and electrical wirings (not shown in the figures) for facilitating the operations of the various components of the apparatus 100. In addition, the control unit 104 comprises exhaust fans configured to cool the components so that they do not overheat.

25 The control unit 104 further comprises wheels 312 for facilitating the movement of the apparatus 100 from one place to another. These wheels 312 are in the form of durable rubber roller wheels. The control unit 104 also comprises a stand 508 which is movable between an extended position and a retracted position. The stand 508 is connected to the bottom drawer tray 502 and is configured to urge against a surface
30 the control unit 104 is placed on when it is in the extended position. This serves to provide greater stability to the control unit 104, which in turn helps to prevent toppling

of the apparatus 100. When moving the apparatus 100, the stand 508 is preferably in the retracted position.

The oxidizing unit 102 will now be described in greater detail.

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Figs. 6(a) and (b) respectively show a front view and a side view of the oxidizing unit 102. The oxidizing unit 102 comprises a mixing unit configured to receive water from the holding space, oxygen and ozone, and further configured to facilitate the mixing of the water with the oxygen and the ozone. In particular, the mixing unit comprises two
10 oxidizing columns 602, 604 which are gas and water tight. Each oxidizing column 602, 604 in turn comprises a narrow cylindrical tube configured to allow water to flow through and a plurality of skewed plates arranged to impact on the water flowing through the tube. More specifically, the plurality of skewed plates are arranged to form a vertical spiral structure along the center of the tube, and are formed of a material that
15 facilitates oxidization of the water.

As shown in Fig. 6(a), the oxidizing columns 602, 604 are arranged parallel to each other and are connected to inlet and outlet pipes. The inlet pipes comprise bottom sockets 606b, bottom 90° elbow joints 608b, a bottom T-joint 610b and a bottom
20 reducing socket 622b, whereas the outlet pipes comprise top sockets 606t, top 90° elbow joints 608t, a top T-joint 610t and a top reducing socket 622t. More specifically, for each oxidizing column 602, 604, one end of the column 602, 604 is connected to a bottom socket 606b whereas the other end of the column 602, 604 is connected to a top socket 606t. The top and bottom 90° elbow joints 608t, 608b respectively connect
25 the top sockets 606t to the top T-joint 610t and the bottom sockets 606b to the bottom T-joint 610b. The top and bottom T-joints 610t and 610b are in turn connected to the top and bottom reducing sockets 622t, 622b respectively. The bottom reducing socket 622b serves as the inlet of the oxidizing unit 102 whereas the top reducing socket 622t serves as the outlet of the oxidizing unit 102. Further, each of the oxidizing columns
30 602, 604 comprises an inlet point (not shown in Figs. 6(a) – (b)) for receiving oxygen from the oxygen concentrator and ozone from the ozone generator of the control unit 104.

The oxidizing unit 102 further comprises a sensing element in the form of a Horiba ORP probe 612 configured to determine an ORP of the water in the holding space. This probe 612 operates using Horiba special KCL liquid and is able to work with the transmitter 306 at the transmitter's 306 factory settings in both freshwater and seawater. The probe 612 is held in a housing 614 in the form of a Horiba special housing. This housing 614 is configured to facilitate the servicing of the probe 612 and the replenishment of the KCL liquid. The housing 614 sits inside a bush that is connected to the bottom T-joint 610b. A Tee joint is connected to the control unit 104 to receive the oxygen from the oxygen concentrator and the ozone from the ozone generator. The Tee joint causes the flow of the oxygen and ozone to split into two separate flows, with one flow entering one end of a first tubing 616 and the other flow entering one end of a second tubing 617. The first and second tubings 616, 617 are in the form of Teflon tubings. The other end of the first tubing 616 is connected to the inlet point of the oxidizing column 604. Similarly, the other end of the second tubing 617 is connected to the inlet point of the oxidizing column 602. This is to provide the oxygen and ozone to the oxidizing columns 602, 604. The tubings 616, 617 are resistant to ozone gas. The oxidizing unit 102 is mounted to the control unit 104 via top and bottom mounting clips 620t, 620b. The oxidizing unit 102 also comprises non-return valves (not shown in the figures) along the inlet and outlet pipes.

In use, the apparatus 100 is arranged proximate the holding space, with the probe 612 and the bottom reducing socket 622b immersed in the water in the holding space. All the breakers and switches of the apparatus 100 are switched on and a submersible pump is connected to the oxidizing unit 102. Fig. 7 shows the oxidizing unit 102 of the apparatus 100 when the apparatus 100 is in use.

The probe 612 continuously determines the ORP of the water in the holding space, whereas the submersible pump continuously urges the water from the holding space to the oxidizing columns 602, 604 via the inlet pipes. In particular, the water entering the inlet (bottom reducing socket 622b) of the oxidizing unit 102 is "split" to pass through the oxidizing columns 602, 604. This allows the oxidizing columns 602, 604 to simultaneously receive the water from the holding space.

The oxygen concentrator generates a continuous supply of oxygen and the oxygen is continuously provided to the oxidizing columns 602, 604 via their respective inlet points. The rate of oxygen generation can be changed using the control knob on the front panel 302 for adjusting the amount of oxygen to provide.

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Oxygen generated by the oxygen concentrator is provided to the ozone generator. When switched on, the ozone generator produces ozone by converting the oxygen enriched air to ozone based on the coronary discharge method. The generated ozone is then provided to the oxidizing columns 602, 604 via their respective inlet points.

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When switched off, this provision of ozone to the oxidizing columns 602, 604 stops. Whether the ozone generator is switched on or off depends on the ORP of the water which will be elaborated later.

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The oxidizing columns 602, 604 provide the gas and effluent interface to facilitate the mixture of the water they receive with the oxygen and the ozone. In particular, the water rising through the oxidizing columns 602, 604 impacts on the skewed plates of each column 602, 604, and the oxygen and ozone is then mixed with the water in the oxidizing columns 602, 604. More specifically, the gases are bubbled into the water. Such dosing of the water with oxygen and ozone serves to treat and disinfect the water, and raise the ORP of the water.

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The treated water is urged out of the columns 602, 604 at the same rate and discharged through the outlet pipes into the holding space. More specifically, the treated water is bubbled out into the holding space by the pumping force provided by the submersible pump. Throughout the process, the water is urged in the direction from the inlet pipes to the outlet pipes using the pump, and is prevented from flowing in the opposite direction by the non-return valves.

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Control of the provision of ozone to the oxidizing columns 602, 604 will now be described in more detail.

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While the oxygen is continuously provided to the oxidizing columns 602, 604, the provision of the ozone to the oxidizing columns 602, 604 is controlled by the control unit (more specifically, the ORP transmitter 306) based on the ORP measurements determined using the probe 612. In other words, whether the ozone generator is switched on depends on the ORP of the water in the holding space as measured by the probe 612.

Fig. 8 shows a method for controlling the provision of ozone to the oxidizing unit 102 according to an embodiment of the present invention. In particular, in step 802, the ORP of the water in the holding space is determined using the probe 612. This ORP is then compared to a lower limit and if the ORP is below or equal to the lower limit, step 804 is performed in which the ozone generator is switched on and the provision of ozone to the oxidizing unit 102 (more specifically, the mixing unit comprising the oxidizing columns 602, 604) starts. After the ozone generator is switched on, in step 806, the ORP of the water in the holding space is again determined and is then compared to an upper limit. If the ORP is above or equal to the upper limit, step 808 is performed in which the ozone generator is switched off to stop the provision of ozone to the oxidizing unit 102. Else, the provision of ozone to the oxidizing unit 102 continues. Steps 802 – 808 are repeated for as long as the apparatus 100 is switched on. In other words, the ORP of the water in the holding space is repeatedly determined and used to decide whether to provide ozone to the mixing unit. The ozone generator remains switched off as long as the ORP measurement stays above the lower limit and once the ozone generator is switched on, it remains in this on state as long as the ORP measurement stays below the upper limit.

To improve the accuracy of the probe 612 measurements, the probe 612 is kept moist and cleaned regularly. The ORP measurements are provided in real-time to the ORP transmitter 306. The comparison of the ORP against the lower and upper limits and the switching of the ozone generator are performed by the transmitter 306. To do so, the transmitter 306 sends signals to the microcontroller of the ozone generator.

The lower and upper limits are obtained based on a set-point input by the user to the ORP transmitter 306. For example, if the user inputs the set-point as 325mV, the interval difference is set as 50mV, and the lower limit is set as 300mV whereas the upper limit is set as 350mV. In this example, if the set-point is changed to 300mV, the
5 interval difference is changed to 100mV, and the lower and upper limits are changed to 250mV and 350mV respectively.

In an alternative embodiment, an apparatus 100' is provided, wherein the apparatus 100' is identical to the apparatus 100, except that it further comprises a communication
10 unit configured to communicate wirelessly with a monitoring unit. The monitoring unit may be in the form of a laptop, computer or a mobile phone, and the communication unit may be configured to communicate with the monitoring unit using WiFi or any other communication technique. In use, data as determined by the apparatus 100' (e.g. the ORP of the water in the holding space, the oxygen level of the water in the holding
15 space, the temperature of the apparatus 100' etc.) is communicated from the apparatus 100' to the monitoring unit via the communication unit. This enables remote monitoring of the apparatus 100' and the water in the holding space.

Various modifications will be apparent to those skilled in the art.
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For instance, the number of oxidizing columns need not be two. The apparatus 100 may comprise more oxidizing columns or may comprise only a single oxidizing column. Further, it is sufficient that the oxidizing columns simultaneously receive water from the holding space and this receipt of water need not be at the same rate. The discharge of
25 the treated water from the oxidizing columns also does not need to be at the same rate.

In addition, although each oxidizing column 602, 604 of the apparatus 100 receives both oxygen and ozone via the same single inlet point, more than one inlet point may be provided for each oxidizing column, and the oxygen and ozone may be received by
30 an oxidizing column via different inlet points.

Also, the user may alternatively input the lower and upper limits directly instead of inputting a single set-point from which the lower and upper limits are calculated as described above. The calculation of the lower and upper limits from a user inputted set-point may also differ from that described above.

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Further, the ozone generator and the oxygen concentrator need not be part of the apparatus 100. Instead, these can be stand-alone systems external to the apparatus 100. It is sufficient as long as the apparatus 100 comprises a sensing element for determining the ORP of the water in the holding space, a mixing unit for mixing the water with the oxygen and ozone, and a control unit (e.g. the transmitter 306) for controlling the provision of the ozone to the mixing unit.

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Different types of oxygen concentrators (or generators) and ozone generators may be used. The oxygen concentrators and ozone generators need not generate the gasses at the rates mentioned above and can be adjusted to generate the gasses at different rates according to the users' needs.

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Also, oxygen need not be provided continuously to the mixing unit. Instead, the provision of oxygen may also be controlled in a similar manner as that for the provision of the ozone.

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Some advantages of the embodiments of the present invention are described below:

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- (a) the embodiments improve the provision of high purity oxygen in the water and are able to provide the oxygen over a longer period of time;
- (b) the embodiments increase the amount of dissolved oxygen in the water;
- (c) the embodiments allow automatic control of the amount of ozone provided to the water;
- (d) the embodiments can be deployed in an open environment and due to its ability to automatically control the amount of ozone provided to the water, farm owners or fish hobbyists need not worry about over-dosing of ozone or having an inadequate amount of ozone in the water;

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- (e) the embodiments can help raise the ORP of the water, in turn increasing the elimination of pathogens from the water;
 - (f) the embodiments can also help eliminate potential pond pollutants that conventional mechanical and biological filtration systems are unable to eliminate;
 - 5 (g) the embodiments are adjustable to vary the amount of ozone provided to the water so they can be used to achieve different water conditions as desired by the user
 - (h) the embodiments can improve fish health, growth, reproduction, colours as they can help increase protection of the fishes from harmful pathogens and protozoan.
- 10 In summary, the embodiments of the present invention can improve the quality of water for rearing aquatic beings such as fishes. A constant oxygen supply and a variable amount of ozone can be provided to the water, allowing fish hobbyists and farm owners to achieve better aquaculture ozonized water treatment. In particular, embodiments of the present invention can provide both oxygen and ozone or oxygen
- 15 alone to the water. Further, unlike other prior art systems, the embodiments of the present invention do not work with a fixed interval of dosing. Instead, the provision of ozone to the water is controlled via a closed-loop process involving the sensing element, the oxidizing unit and the control unit.

Claims

1. An apparatus for treating water for rearing aquatic beings, wherein the water is held in a holding space and wherein the apparatus comprises:

5 a sensing element arranged within the holding space and configured to determine an Oxidation-Reduction Potential (ORP) of the water in the holding space;

a mixing unit configured to receive water from the holding space, oxygen and ozone, and further configured to facilitate mixture of the water with the oxygen and the ozone; and

10 a control unit configured to control provision of the ozone to the mixing unit based on the determined ORP;

wherein the mixing unit comprises a tube configured to allow water to flow through and a plurality of skewed plates arranged to impact on the water flowing through the tube.

15 2. An apparatus according to claim 1, wherein the control unit is configured to start providing ozone to the mixing unit if the ORP is equal to or below a lower limit and is further configured to stop said provision of the ozone to the mixing unit when the ORP reaches equal to or above an upper limit.

20 3. An apparatus according to claim 1 or 2, wherein the control unit further comprises:

an oxygen concentrator configured to generate the oxygen; and

an ozone generator configured to generate the ozone.

25 4. An apparatus according to claim 3, wherein the ozone generator is configured to generate the ozone using the oxygen generated by the oxygen concentrator.

5. An apparatus according to claim 3 or 4, wherein the control unit further comprises a perforated tray configured to hold the ozone generator.

30 6. An apparatus according to any one of the preceding claims, wherein the oxygen is continuously provided to the mixing unit.

7. An apparatus according to any one of the preceding claims, wherein the mixing unit comprises a plurality of oxidizing columns configured to simultaneously receive water from the holding space and further configured to facilitate the mixture of the received
5 water with the oxygen and the ozone.

8. An apparatus according to claim 7, wherein the mixing unit comprises two oxidizing columns.

10 9. An apparatus according to claim 1, wherein the plurality of skewed plates are arranged to form a vertical spiral structure along the center of the tube.

10. An apparatus according to any one of the preceding claims, wherein the water is urged through the mixing unit in an urging direction and wherein the apparatus further
15 comprises non-return valves configured to prevent flow of the water opposite to the urging direction.

11. An apparatus according to any one of the preceding claims, further comprising a casing formed of stainless steel.

20 12. An apparatus according to any one of the preceding claims, further comprising a communication unit configured to communicate wirelessly with a monitoring unit.

25 13. A method for treating water for rearing aquatic beings, wherein the water is held in a holding space and wherein the method comprises repeatedly performing the following steps:

urging the water from the holding space through a mixing unit;
providing the mixing unit with oxygen for mixing with the water;
determining an Oxidation-Reduction Potential (ORP) of the water in the holding
30 space using a sensing element immersed in the water in the holding space; and

controlling provision of ozone to the mixing unit for mixing with the water, wherein the controlling is based on the determined ORP and is performed using a control unit;

5 wherein the mixing unit comprises a tube configured to allow water to flow through and a plurality of skewed plates, and the method further comprises impacting the water on the plurality of skewed plates as the water is flowing through the tube.

14. A method according to claim 13, wherein using the control unit comprises configuring the control unit to start providing ozone to the mixing unit if the ORP is
10 below or equal to a lower limit and to stop said provision of the ozone to the mixing unit when the ORP reaches above or equal to an upper limit.

15. A method according to claim 14, further comprising:

15 setting a set-point for the ORP of the water in the holding space; and calculating the lower limit and the upper limit based on the set-point using the control unit.