

SYSTEM AND METHOD FOR TREATING RAW WATER

Field of Invention

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This invention relates to a system and method for treating raw water. In particular, the invention relates to a system and method for treating raw water incorporating a gravity flow membrane filter system to produce water suitable for human consumption.

10 Background of Invention

City dwellers often take the availability of potable water for granted. Cities usually have huge water treatment plants that are able to support and supply volumes of potable water to large portions of the city's population. Raw water is collected from various sources and is conveyed to treatment plants by pipelines where it is physically and chemically treated, filtered and disinfected. The water is treated to remove harmful pathogens and made safe for consumption. Such treatment plants are relatively expensive to operate and require the use of electrical energy.

20 However, in rural and remote parts of the world where there is little infrastructure to support such a large water treatment plant, water sources in these areas are not only scarce but may be contaminated with physical particulates, or biologically contaminants such as waterborne pathogens.

25 Also, in these circumstances, often malfunctioning or even non-existing sanitation causes pollution, especially of the pathogenic nature, of water bodies used for drinking water purposes. This concerns human excrement as well as animal excrement.

Therefore, there is a need to provide for an inexpensive and easy-to-maintain system for treating raw water to produce water suitable for human consumption in remote areas where there is little electricity or infrastructure to support the usual water treatment.

Summary of Invention

In accordance with a first aspect of the invention, there is provided a system for treating
5 raw water to produce water suitable for human consumption, the system comprising (a) a
tank having an inlet for receiving the raw water and an outlet for discharging the treated
water, the inlet and outlet positioned at a first and second level respectively; and (b) at
least one membrane filter module in the tank downstream the inlet, the membrane filter
module interposed between the inlet and the outlet, wherein the outlet is at a level lower
10 than the inlet.

By “tank”, it is meant to include any container for containing water to be treated and at
least one filter membrane.

15 Preferably, the system is independent of a power source. Advantageously, water is passed
through the membrane filter unit by gravity flow without the use of any power source. As
the water is passing through the membranes, particulate matter and pollutants as well as
pathogenic bacteria are almost completely retained by the membrane and thus are
removed from the treated and filtered water with a Log Reduction Value (LRV) of at
20 least 3.

Preferably, the outlet of the tank is a lead-through and is in fluid communication with an
outlet of the membrane filter module.

25 Preferably, the at least one membrane filter module includes a flat sheet membrane filter.

Preferably, the at least one membrane filter unit includes a hollow fibre membrane.

Preferably, the system comprises a plurality of membrane filter modules. The plurality of
30 membrane filter modules may be contained in a membrane filter tank. More preferably,
the system comprises a plurality of membrane filter tanks.

Preferably, the membrane filter module is in fluid communication with a storage tank for storing the discharged treated water.

- 5 Preferably, the system further comprises a storage tank for storing the discharged treated water before being discharged or distributed to water consumers. In the case where the system comprises a plurality of membrane filter units, each membrane filter unit is in fluid communication with a storage tank for storing the discharged treated water. The storage tank is located at a level lower than the outlet of the membrane filter modules or tanks. More preferably, the storage tank further includes an ultraviolet disinfection unit for providing ultraviolet radiation. The disinfection unit may, alternatively or in addition, include a means for dispensing chlorine.

Preferably, the inlet includes a sieve for trapping particulate matter.

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Preferably, a pump pumps raw water to the system from a river, lake, canal or underground well. The pump is preferably independent of the system, since the system may be independent of a power source. Raw water may be introduced into the system of the present invention by any relevant method known to the skilled person.

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- In accordance with a second aspect of the present invention, there is provided a method for treating raw water to produce water suitable for human consumption, the method comprising: (a) receiving the raw water from a source; (b) using gravity to pass water through an inlet of a tank, the tank having at least one membrane filter module downstream the inlet; and (c) collecting the treated water through an outlet of the tank, wherein the outlet is at a level lower than the inlet

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- Preferably, the method is independent of a power source. Advantageously, water is passed through the membrane filter unit by gravity flow without the use of any power source to drive a pump. As the water is passing through the membranes, particulate

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matter and pollutants as well as pathogenic bacteria are retained by the membrane and thus are removed from the treated and filtered water.

5 Preferably, the outlet of the tank is a lead-through and is in fluid communication with an outlet of the membrane filter module. Preferably, the outlet is at a level lower than the water level in the tank.

Preferably, the water is passed through at least one flat membrane sheet filter in the at least one membrane filter module.

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Preferably, the water is passed through a plurality of flat membrane sheet filters in the at least one membrane filter unit.

15 Preferably, or alternatively, the water is passed through at least one hollow fibre membrane filter in the at least one membrane filter module..

Preferably, the method is a continuous processing operation.

20 Preferably, the treated water is disinfected with ultraviolet radiation. The subsequent ultraviolet disinfection assures that the treated water is of drinking water quality is. Alternatively, the treated water is disinfected by means of chlorination.

25 Preferably, the treated water is stored and then distributed into a local water distribution network. Preferably, the raw water is stored in a raw water storage tank prior to being passed through the inlet of the tank.

Preferably, the treated water has a Log Reduction Value (LRV) of at least 3. More preferably, the treated water has a Log Reduction Value (LRV) of at least 4.

30 Preferably, the distance between the water level in the tank and the outlet is at least 80cm.

Brief Description of Figures

In order that the present invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative examples only preferred
5 embodiments of the present invention, the description being with reference to the accompanying illustrative figures.

In the Figures:

10 Figure 1 is a schematic drawing of the system according to an embodiment of the present invention;

Figure 2 is a schematic drawing of the system according to another embodiment of the present invention; and

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Figure 3 is a schematic drawing of the system according to another embodiment of the present invention.

Detailed Description of The Preferred Embodiments

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Referring to the accompanying drawings, Figure 1 shows a tank 10 comprising a cover 70 having an inlet RW for receiving raw water. Downstream the inlet RW is a membrane filter module 25. The water level when the tank is filled with water is shown by water level 15. The membrane filter module 25 is interposed between the inlet RW and lead-through 20. The raw water RW is filled into the tank 10 and the treated water TW is
25 discharged via the lead-through 20 and a membrane filter effluent pipe 50. The water level 15 and lead-through 20 may be positioned at levels A and B respectively as shown by the relevant dotted lines in Figure 1. In an embodiment of the invention, the lead-through 20 is positioned at a level lower than the water level 15. From Figure 1, it can be
30 seen that the water level 15 is located near the top level of the tank 10 while lead-through 20 is positioned near the bottom level of the tank 10. The difference in height is shown as

d , representing the water level difference before and after passing the membrane filter module 25. This creates a transmembrane pressure (TMP) that forms the driving force to pass the water through the membranes. The higher the water level difference d , the higher the TMP and the greater the flux of water through the membranes. The positions of the water level 15 and lead-through 20 ensure that there is sufficient TMP, i.e. water level difference before and after the membranes, in order to achieve a desired flux. Preferably, in an embodiment of the present invention, d is at least about 80cm. However, a skilled person can vary d in order to achieve a desired or optimum flux.

10 The membrane filter module 25 is preferably mounted at a certain distance from the base of the tank 10. Preferably, the membrane filter module 25 is about 10cm above the base of the tank 10. There should be water retained in the tank 10 such that the membrane filter module 25 is fully immersed in water. Preferably, the water level is about 30cm higher than the membrane filter module 25. The depth of the water level inside the tank 15 10 is thus determined by the height of the membrane filter module 25 in the tank 10 plus the distance between the membrane filter module 25 and the base of the tank 10 plus the desired water depth above the membrane filter module 25.

Figure 2 shows a further embodiment of the present invention shown in Figure 1. In addition to the tank 10, and all the features associated with the tank 10 as shown in Figure 1, Figure 2 includes further features that will now be described in detail.

Polluted raw water RW may be stored in a raw water storage tank 30 which preferably may be provided with a cover 95 before being fed into the tank 10 via a connection channel 35. The connection channel connects the raw water storage tank 30 to the tank 10 via RW on the cover 70. The connection channel 35 may include a sieve 40 for removing coarse material (for example, any particulate matter such as stones, sand or leaves) from the raw water. Alternatively, the sieve 40 may be placed anywhere along the connection channel 35 or preferably in influent of the raw water storage tank 30. The sieve 40 may have a slit geometry or a hole geometry. Preferably, the width of the slit sieve or diameter of the hole sieve shall not be larger than 2mm.

The connection channel 35 is in fluid communication with the raw water storage tank 30 and tank 10.

- 5 In an alternative embodiment, the raw water is directly pumped into the membrane filter module 25, provided that the pump that pumps the raw water has a sieve in order to prevent larger particles from being pumped into the membrane filter module 25. The sieve may have holes having pre-determined diameters to trap the particulates in the raw water.

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- A plurality of membrane filter modules 25 may be placed in the tank 10. In other words, the present water treatment system may be a modular system consisting of a plurality of membrane filter modules 25 that may be removable. In an embodiment of the invention, 1 or 2 or 3 or 4 membrane filter modules may be used according to the required capacity
15 of the system. The system of 1 to 4 membrane filter module 25 may be equipped with only one connection channel 35 to achieve an even hydraulic load of the 1 to 4 membrane filter units.

- Each membrane filter module 25 may comprise of any suitable membrane filter or filters
20 known to the skilled person that are suitable for filtering and treating raw water in order to remove pollutants, especially particulate matter and pathogens, with a very high efficiency. For example, flat sheet membrane modules may be obtained commercially from Kubota, Weise Water Systems, Martin Systems, Microdyn Nadir and others. Hollow fibre membrane modules may be obtained commercially from GE Zenon,
25 Siemens USF, Mitsubishi Rayon and others. Nominal pore width of the membranes used shall preferably be equal or below 40 nanometer, offering a narrow pore width distribution and a high permeability, the maximum pore diameter being less than 100 nanometer. In an embodiment of the invention, the membranes of the membrane filtration module 25 are flat sheet membranes, the flat sheets being mounted vertically in the tank
30 10. The water can penetrate from outside the membrane through the membrane into the inner part of the membrane flat sheet filter and being conducted to the membrane filter

effluent pipe 50. By passing the membrane or membranes, the raw water is filtered and flows to the membrane filter effluent pipe 50, leaving the tank 10 via the lead-through 20.

Alternatively, in another embodiment of the invention, a hollow fiber membrane may be used in the membrane filter module 25. The water is fed to the outside of the membrane fiber and penetrates the membrane into the lumen of the fibers. The filtered and treated water is then collected at the outlet of the fibers connected to the membrane filter effluent pipe 50, leaving the tank 10 via the lead-through 20.

Downstream the tank 10, the membrane filter effluent pipe 50 is in fluid communication with a treated water storage tank 45, which preferably may have a cover 100. A distribution pipe 60, which may preferably include an ultraviolet disinfection unit 55, distributes the treated water to a plurality of water taps 65. Alternatively or additionally, the treated water storage tank 45 may include a disinfection unit that introduces chlorine into the treated water. Still more alternatively, the membrane filter effluent pipe 50 may be connected to a disinfection unit 90 that releases chlorine into the treated water, and the treated and chlorinated water may be fed into the treated water storage tank 45.

It will be appreciated that there may be a plurality of tanks 10. Within each tank 10, there may be a plurality of membrane filter modules 25. In the case where there is more than one tank 10, the water treatment system may be equipped with one common treated water storage tank 45 in order to achieve maximum operational flexibility. Alternatively, each tank 10 may be equipped with a separate treated water storage tank 45.

Figure 3 shows a further embodiment of the present invention as shown in Figure 2. In this embodiment, the raw water storage tank 30 and the connection channel 35 are omitted. Instead, the raw water directly is fed into the one or a plurality of tank(s) 10.

In operation, raw water may be collected and stored in the raw water storage tank 30. In essence, raw water is passed through the system by gravity flow without the use of any external power source. The system capitalizes on gravity to allow water to flow through

the system including the membranes. This effect is achieved by positioning the outlet 20 at a position or level lower than the water level 15. In other words, water is allowed to flow in a “top to bottom” manner by gravity. The membrane filter module 25 is below or downstream the water level 15, thus immersed in the raw water to be treated. As raw water enters the tank 10 at RW in the cover 70, it continues to flow downstream by passing through the membranes of the membrane filter module 25. Particulate matter and pollutants as well as pathogenic bacteria are retained by the membranes with a high log reduction value of at least 3 or 4 and thus are removed from the filtered water. The filtered water exits at the membrane filter module 25 via the membrane filter effluent pipe 50. The membrane filter effluent pipe 50 ends in the storage tank 45. Preferably, the water when flowing through the membrane filter effluent pipe 50 is fed to a disinfection unit 90 applying chlorination. Preferably, the disinfection unit 90 operates on a mechanical principle without the need of electric energy. Alternatively, the unit may comprise of a dosing pump operated by electric energy.

The membrane system is independent from an external electric power supply and is operated only by gravity. The required TMP necessary to make the water pass through the membranes is provided by the water level difference d between the water level in the tank 10 and the level of the lead-through 20 of the tank 10.

As only the water can pass through the membranes, whereas particulate matter and pollutants as well as pathogenic bacteria are retained by the membranes, the water, after having passed the membrane filter device, is preconditioned in an optimal and innovative way for undergoing further treatment steps by means of a disinfection unit 90 that may, for example, apply chlorine to the water and/or an ultraviolet disinfection unit 55. If chlorination is included, then the treated water TW achieves drinking water quality concerning hygienic requirements.

The membrane filter modules are suitable for continuous operation. Because the water treatment can be operated continuously, but the water users will gather the drinking water discontinuously from the system, the installation of a treated water storage tank 45 allows

the treated water to be stored prior to use. The filtered water TW from the tank 10 will flow via the membrane filter effluent pipe 50 into the treated water storage tank 45.

As a further step of treatment, the filtered water is disinfected by means of chlorination
5 by a chlorination unit or by ultraviolet radiation. The disinfection unit 90 may be installed in the membrane filter effluent pipe 50. The ultraviolet radiation unit 55 may be installed in the water distribution pipe 60. Alternatively the disinfection unit 90 may be installed inside the treated water storage tank 45. A solar power supply, eventually including a battery station for night time operation, provides the necessary very low power
10 consumption for the ultraviolet disinfection unit 55, if no electric network is available. The required electrical power can be supplied from a local electricity network, if available, or can be obtained by a photovoltaic solar panel combined with a battery to allow continuous operation. Alternatively, disinfection may be carried out by means of chlorination. The disinfection by chlorination is achieved in the treated water storage tank
15 45 and shall provide water with a residual content of chlorine of 0.3 to 0.5mg/l. If chlorination is not required by local authorities or regulations, then the disinfection may be carried out by means of ultraviolet radiation. Other post treatment steps like adjustment of pH can be included, but are not described here.

20 For maintenance reasons, the raw water storage tank 30, the tank 10 and the treated water storage tank 45 must be equipped with bottom outlets 75, 80 and 85 respectively. In order to control and minimize the thickness of the cake layer which will be formed on the feed side of the membranes due to retaining particulate matter, there may be an aeration installed on the bottom side of the membrane modules, providing for an upwards flow of
25 water and air, which is known as crossflow aeration. In this case, a blower is to be included. The required electrical power can be supplied from a local electricity network, if available, or can be obtained by a photovoltaic solar panel, preferably combined with a battery to allow continuous operation.

30 If the membrane filter module(s) 25 is/are covered or blocked by retained polluting matter and the flux of the membrane filter decreases to below the nominal capacity of the

filter, it is necessary and possible to clean the membrane filter module(s) 25. This cleaning can be achieved either directly inside the tank 10 by means of flushing with clean water or, depending on the membrane modules type, by creating backflow through the filter. As alternative solution, also chemical cleaning of the membranes is possible, 5 using any chemical in any concentration as recommended and endorsed by the membrane module supplier, typically NaOCl in a concentration ranging between 100 mgCl/Liter to 500 mgCl/Liter.

10 A pump may be used to pump raw water from a river, lake, canal or groundwater well to tank 10 or the raw water storage tank 30. The pump may be driven by any kind of available power, preferably using a pump, driven by an electric motor. If a local water distribution network is already existing, the treated water can also be fed into this network.

15 Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention.

CLAIMS

1. A system for treating raw water to produce water suitable for human
5 consumption, the system comprising:
 - (a) a tank having an inlet for receiving the raw water and an outlet for discharging the treated water, the inlet and outlet positioned at a first and second level respectively; and
 - (b) at least one membrane filter module in the tank downstream the inlet, the membrane filter module interposed between the inlet and the outlet,
10 wherein the outlet is at a level lower than the inlet.
2. The system according to claim 1, wherein the system is independent of a power source.
- 15 3. The system according to any one of claims 1 or 2, wherein the treated water has a Log Reduction Value (LRV) of at least 3.
4. The system according to any one of the preceding claims, wherein the outlet of the tank is a lead-through and is in fluid communication with an outlet of the membrane
20 filter module.
5. The system according to any one of the preceding claims, wherein the at least one membrane filter module includes a flat sheet membrane filter.
- 25 6. The system according to any one of claims 1 to 4, wherein the at least one membrane filter module includes a hollow fibre membrane.
7. The system according to any one of the preceding claims, wherein the system comprises a plurality of membrane filter modules.
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8. The system according to claim 7, wherein the plurality of membrane filter modules are contained in a membrane filter tank.

5 9. The system according to claim 8, wherein the system comprises a plurality of membrane filter tanks.

10 10. The system according to any one of the preceding claims, wherein the membrane filter module is in fluid communication with a storage tank for storing the discharged treated water.

11. The system according to any one of the preceding claims, wherein the system further comprises a storage tank for storing the discharged treated water.

15 12. The system according to any one of claims 10 or 11, wherein the storage tank further includes a disinfection unit.

13. The system according to claim 12, wherein the disinfection unit includes a means for dispensing chlorine.

20 14. The system according to claim 12, wherein the disinfection unit includes a means for providing ultraviolet radiation.

25 15. The system according to any one of the preceding claims, wherein the inlet includes a sieve for trapping particulate matter.

16. The system according to any one of the preceding claims, wherein a pump pumps raw water to the system from a river, lake, canal or underground well.

30 17. The system according to any one of the preceding claims, wherein the system is part of a local water distribution network.

18. A method for treating raw water to produce water suitable for human consumption, the method comprising:

- (a) receiving the raw water from a source;
- (b) using gravity to pass water through an inlet of a tank, the tank having at least one
5 membrane filter module downstream the inlet; and
- (c) collecting the treated water through an outlet of the tank,
wherein the outlet is at a level lower than the inlet.

19. The method according to claim 18, wherein the method is independent of a power
10 source.

20. The method according to any one of claims 18 or 19, wherein the outlet of the tank is a lead-through and is in fluid communication with an outlet of the membrane filter module.

21. The method according to any one of claims 18 to 20, wherein the outlet is at a level lower than the water level in the tank.

22. The method according to any one of claims 18 to 21, wherein the water is passed
20 through at least one flat membrane sheet filter in the at least one membrane filter module.

23. The method according to any one of claims 18 to 21, wherein the water is passed through at least one hollow fibre membrane filter in the at least one membrane filter module.

24. The method according to any one of claims 18 to 23, wherein the method is a continuous processing operation.

25. The method according to any one of claims 18 to 24, wherein the treated water is
30 disinfected with ultraviolet radiation.

26. The method according to any one of claims 18 to 25, wherein the treated water is disinfected by means of chlorination.

27. The method according to any one of claims 18 to 26, wherein the treated water is stored and then distributed into a local water distribution network.

28. The method according to any one of claims 18 to 27, wherein the raw water is stored in a raw water storage tank prior to being passed through the inlet of the tank.

29. The method according to any one of claims 18 to 28, wherein the treated water has a Log Reduction Value (LRV) of at least 3.

30. The method according to any one of claims 18 to 29, wherein the distance between the water level in the tank and the outlet is at least 80cm.

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