



WATER TREATMENT METHOD AND APPARATUS

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for treatment of
5 waste water, in particular black and grey household waste water.

BACKGROUND TO THE INVENTION

Many homes are located in small or rural communities where houses are
spaced widely apart. In these communities, central sewerage systems are often
not cost-effective, so many homeowners rely on septic systems or other systems
10 that treat and dispose of household wastewater onsite.

It is however often difficult to install systems which treat and dispose of
household wastewater to a sufficient and safe level, without posing health risks to
the homeowners and the environment. This is especially the case in relation to
black water from sanitary systems such as toilets.

15 Furthermore, systems currently available are bulky, heavy and time
consuming to install, especially in unsophisticated regions without access to high
powered tools, and machinery.

It is therefore desirable to provide a water treatment method and apparatus
which ameliorates at least some of the above concerns.

20 SUMMARY OF THE INVENTION

In one aspect, the present invention provides a water treatment apparatus
for the treatment of household waste water, the apparatus comprising a plurality
of chambers for receiving the waste water, the chambers arranged to allow the
waste water to undergo a series of treatments to produce a treated effluent,
25 wherein the plurality of chambers includes at least one anaerobic chamber
adapted to treat said waste water with anaerobic processes, and at least one
aerobic chamber adapted to treat said anaerobically treated waste water with
aerobic processes.

In a second aspect, the present invention provides a method for the
30 treatment of household waste water in a treatment tank comprising a plurality of
chambers arranged to allow the waste water to undergo a series of treatments to
produce a treated effluent, the method including the steps of: allowing the waste
water to enter at least one anaerobic chamber in the treatment tank adapted to



treat said waste water with anaerobic processes; and allowing the waste water to enter at least one aerobic chamber in the treatment tank adapted to treat said anaerobically treated waste water with aerobic processes.

5 The at least one anaerobic chamber may comprise a first anaerobic chamber having suspended acetogenic bacteria for treating said waste water, and a second anaerobic chamber having suspended methanogenic bacteria for further treating said waste water subsequent to treatment of said waste water in said first anaerobic chamber. The at least one aerobic treatment chamber may comprise a first aerobic chamber having roots of plant matter with added oxygen.

10 In one form, there further comprises a mixing chamber adapted to receive and mix anaerobically treated waste water with additional untreated waste water. Preferably, the anaerobically treated waste water comprises waste water treated in both the first and second anaerobic chambers, the initial untreated waste water comprising black water, and the additional untreated waste water comprises grey
15 water.

In another form, the at least one anaerobic chamber further comprises a third anaerobic chamber comprising a filter media having attached bacteria cultures for further treating the waste water subsequent to treatment of the waste water in the first and second anaerobic chambers. The third anaerobic chamber is
20 preferably arranged to further treat the waste water subsequent to the waste water leaving the mixing chamber, but prior to treatment of the waste water in the first aerobic chamber.

Forms of the present invention can treat both black and grey household waters. In one form, treatment may be undergone on initial untreated waste water
25 comprising a Biochemical Oxygen Demand (BOD) of about 800 to 1200 mg/L, a Chemical Oxygen Demand (COD) of about 900 to 1500 mg/L, and a settleable solids to COD ratio of about 0.40 to 0.60, preferably 0.43.

Preferably, the effluent will meet the USEPA regulations of a BOD of less than 100 mg/L for surface discharge and less than 50 mg/L for discharge into
30 water bodies. Using the above parameters, the final treated effluent will preferably be of sufficient quality for surface discharge, discharge to the rainwater drain or for aqua-culture, with a BOD of less than 15mg/L, and a COD of less than 50mg/L.

Embodiments of the present invention may be used by households, in particular, where the apparatus comprises a modular tank adapted to be flat-packed prior to use. In such case, it is preferred the volume of the tank is about 1200 L.

5 Advantageously, forms of the present invention can handle all the wastewater generated in a home, ie the black water from the toilets, and the grey water from the rest of the home. This provides the end-user a one point solution for all the water management issues.

10 In addition, the invention is designed on the principles of anaerobic digestion, in the context of a relatively less BOD effluent with high degree of dilution. Not only is the BOD removed, but also the nitrogen and phosphorus. This ensures that even if the water is drained to receiving water bodies, the incident of algal blooms is minimised to a large degree. This provides a sufficiently treated final effluent quality suitable for reuse in the environment. The processes for the
15 treatment of the waste water are good for the environment, all being natural processes without use of any chemicals.

Using a modular tank in some forms, which may ideally be flat packed prior to use allows for ease of storage and transportation, and can be assembled and installed at site in less than 2 - 3 hours. The tank, therefore, is most
20 advantageous even at locations stuck by natural disasters where the survivors are often faced with an epidemic breakout due to water contamination.

Furthermore, forms of the present invention decompose more than 95% of the organic matter, thereby producing very little sludge, allowing for a de-sludging interval as high as six years.

25 **BRIEF DESCRIPTION OF THE DRAWINGS**

An illustrative embodiment of the present invention will now be described with reference to the accompanying figures. Further features and advantages of the invention will also become apparent from the accompanying description.

Figure 1A shows a water treatment apparatus comprising a treatment tank
30 in accordance with one embodiment of the present invention installed in a yard;

Figure 1B shows the means for connecting the toilet water and kitchen water to the treatment tank of Figure 1A;

Figure 2 is a perspective view of the treatment tank of Figure 1 in greater detail;

Figure 3 is a cross sectional view of the treatment tank of Figure 2, with part of the exterior shell removed;

5 Figure 4 is perspective view of the treatment tank of Figure 2 with the part of the exterior shell removed, showing part of the interior of the tank;

Figure 5 is another perspective view of the treatment tank of Figure 2 with part of the exterior shell removed, showing part of the interior of the tank;

10 Figure 6 is another perspective view of the treatment tank of Figure 2 with part of the exterior shell removed, showing part of the interior of the tank;

Figure 7 is yet another perspective view of the treatment tank of Figure 2 with part of the exterior shell removed, showing part of the interior of the tank;

Figure 8 is yet another perspective view of the treatment tank of Figure 2 with part of the exterior shell removed, showing part of the interior of the tank;

15 Figure 9 is a further cross sectional view of the treatment tank of Figure 2;

Figure 10 shows the treatment tank of Figure 2 with the final treated effluent being removed from the tank;

Figures 11A to 11H show the treatment tank of Figure 2 converting from a flat packed arrangement.

20 **DESCRIPTION OF PREFERRED EMBODIMENT**

25 The following is a non-limiting description of one embodiment of the present invention. It will be appreciated however by those skilled in the art that other features and embodiments may be implemented which still fall within the spirit and scope of the invention. It is clear that there may be variations in the size and shape of the apparatus, in the materials used in the construction and in the orientation of the various parts and devices of the apparatus.

30 The water treatment method of the present embodiment is carried out using a treatment tank 10 as shown in Figure 1A. The type of treatment carried out in the tank 10 includes biological, anaerobic and aerobic post treatment. The treatment tank can be stored underground in the yard of a house. Pipes 12 as shown in Figure 1B connect the outlets from the toilet water 14 and kitchen water 16 to the tank 10, preferably by installing the pipes underground.

The exterior of the treatment tank 10 is shown in Figure 2. Preferably, the volume of the tank 10 is approximately 1.2 cubic meters, with a length of 1.8 meters, width of 1.4 meters, and depth of 1.0 meters at the centre point. The exterior shell of the tank 10 is moulded in two sections from Fibre Reinforced Plastic (FRP), although other suitable materials could be used, such as polyethylene for example. Each section has a rounded shape, with no edges or vertices, and is elongated so as to distribute the pressure on any surface. At peak load, each tank 10 can take a peak load of waste from 8 persons. The construction of the tank 10 is robust to take shock loads, equivalent to the wastes generated by 3 additional people a short period time, eg 2-3 days.

Inlet pipes 18, 20 are located at the upper wall of the tank 10 to connect to the pipes 12 from the toilet water and kitchen water outlets 14, 16 respectively.

Figure 3 shows the interior of the tank, with the upper exterior shell removed. The tank 10 includes five operational chambers 22, 26, 28, 30 and 32 separated by baffle walls 24, 27, 29, with flow regulators to optimize tank's 10 efficiency.

The tank 10 may be directly connected to the household sanitary system, or alternatively the black water may be first captured in a storage tank. Preferably, the blackwater pipe 12 has an intermediate inspection chamber to avoid the transport of debris/rubbish flushed into the toilet, with the treatment tank 10 then connected to the storage tank for subsequent treatment. Preferably, the waste water influent quality includes a Biochemical Oxygen Demand (BOD) of about 1200 mg/L, a Chemical Oxygen Demand (COD) of about 1500 mg/L, and a settleable solids to COD ratio of about 0.43.

The black water including human or animal waste matter from a sanitary system such as a toilet flows into the first anaerobic chamber 22, as shown in detail in Figure 4, and then through baffle wall 24 into the second anaerobic chamber 26, as shown in detail in Figure 5.

The first anaerobic chamber 22 in the tank 10 is the first of two anaerobic reactors. The first anaerobic chamber 22 includes suspended acetogenic bacteria for breaking down the waste products to form acetate, and produce hydrogen and carbon dioxide, while the second anaerobic chamber 26 includes suspended methanogenic bacteria for converting the acetate or carbon dioxide and hydrogen

into methane. This two chambered anaerobic reactor provides the ideal treatment for the arriving faecal matter. The bacterial concentration in both chambers is self generating and thereby provides continuous and consistent treatment to the influent black water.

5 From the two anaerobic chambers 22, 26, the partially treated black water then flows through a baffle wall 27 into a mixing or equalization chamber 28, as shown in detail in Figure 6. In the equalization chamber 28, the black water mixes with less polluted grey water which enters the tank 10 at this chamber 28 via inlet 20 connected to a pipe 12 from the household water system. The purpose of the
10 equalization chamber 28 is to blend the black and grey waters to thereby dilute the influent sewage for optimal filtration in the subsequent anaerobic filter.

 The grey water entering the tank 10 via inlet 20 will preferably be devoid of oils and grease, as these will have been removed by a grease trap (not shown). Alternatively, the anaerobic bacteria will consume oils in the grey water, and
15 accordingly a grease trap will not be required.

 The diluted solution then flows into a third anaerobic chamber 30, as shown in detail in Figures 7 and 8, being the final anaerobic stage of the system, to bio-filter through attached bacterial cultures. The bio-filter performs with the attached cultures of bacteria on filter media, generally plastic, which provides a
20 large surface area for the bacteria to attach.

 Once the influent has flowed through the four chambers, preferably over 90% of the organic matter will have been removed. The partially treated mixed effluent then undergoes a final post treatment unit in an aerobic chamber 32, by flowing through an aerobic bio-filter or French drain. This process is performed in
25 the final unit of the tank 10, as shown in detail in Figure 9. The aerobic bio-filter includes roots of plant matter 34 and gravel 36 with added oxygen, and accordingly the effluent acts on a series of biochemical aerobic and anaerobic reactions, and more importantly, oxidizing the remaining influent. The roots 34 also remove the nutrients of nitrogen and phosphorus.

30 The French Drain is a modified version of leachfield. It is constructed in the body of the tank from FRP. The optional Bio-filter is part of the tank and is also constructed with FRP.

The design of the treatment tank 10 is a continuous flow system. Therefore, the overall retention times are taken into consideration which neutralizes the effects of flow variations.

Once the treatment process has been completed, the final effluent 38,
 5 should be below the United States Environment Protection Agency (US EPA) specifications for surface discharge and for discharge into flowing waters, and thus is fit for reuse in the environment, for example for surface discharge, discharge to the rainwater drain or for aqua-culture, as shown in Figure 10. Typically, the final effluent quality will be BOD of less than 15mg/L, and COD of
 10 less than 50mg/L.

The sludge that is left behind after the full treatment process is an ideal soil conditioner, and can be applied on to the garden or agricultural land. Advantageously, the de-sludging interval will be as high as 6 years due to the complex set of anaerobic reactions in the tank, converting more than 95% of the
 15 organic matter into gas.

The treatment system by utilizing the tank 10 is capable of handling grey water up to 80L per capita per day, and black water up to 20L per capita per day, and would produce less than 3 kg of sludge per capita per year. The flow rate for the tank 10 is approximately 120-160 L per day.

20 Advantageously, the tank 10 is designed to handle all the wastewater generated in a home, ie the black water from the toilets, and the grey water from the rest of the home. This provides the end-user a one point solution for all the water management issues.

The treatment system is one of the most relevant solutions for today's
 25 global sanitation distress. The treatment tank is designed on the principles of anaerobic digestion, in the context of a relatively less BOD effluent with high degree of dilution. It also factors in the real-time scenarios of how families behave and perform within the context of a home, and thereby is robust to take shock loads.

30 Furthermore, the treatment tank addresses a series of practical issues. The tank can be flat packed and assembled and installed at site in less than 2 - 3 hours, as shown in the series of Figures 11A to 11H. The tank 10 is brought to the site in units. The tank, therefore, is ideal even at locations stuck by natural

disasters where the survivors are often faced with an epidemic breakout due to water contamination.

The exterior shell of the tank is in two parts 10a and 10b, with the remaining units stored inside one part of the tank 10a, as shown in Figure 11A.

- 5 The two parts 10a and 10b of the exterior shell are separated from each other, as shown in Figure 11B. The first baffle wall 24 is removed from the inside the shell as shown in Figure 11C, and inserted into the correct position in the lower part of the exterior shell, as shown in Figure 11D. The remaining two baffle walls 27, 29 are then similarly removed from the stored position and inserted into their correct
- 10 locations in the lower part of the exterior shell, as shown in Figure 11E. Once the interior baffles are in place, the upper exterior shell can then be assembled over the baffle walls 24, 27, 29 and connect to the lower exterior shell, as shown in Figure 11F. The inlet and outlet pipes 18, 19, 20, 21 are also inserted into their correct positions and locked in place with the upper exterior shell at this time.
- 15 Figures 11G and 11H show the tank fully assembled.

It will be appreciated that persons skilled in the art could implement the present invention in different ways to the one described above, and variations may be produced without departing from its spirit and scope.

- Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment.
- 20 Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more combinations.
- 25

- Any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the invention. It should not be taken as an admission that any of the material forms part of the prior art base or
- 30 the common general knowledge in the relevant art, in any country, on or before the filing date of the patent application to which the present specification pertains.

CLAIMS:

1. A water treatment apparatus for the treatment of household waste water, the apparatus comprising a plurality of chambers for receiving the waste water, the chambers arranged to allow the waste water to undergo a series of
5 treatments to produce a treated effluent, wherein the plurality of chambers includes at least one anaerobic chamber adapted to treat said waste water with anaerobic processes, and at least one aerobic chamber adapted to treat the anaerobically treated waste water with aerobic processes.
2. A water treatment apparatus according to any one of preceding claims,
10 wherein the waste water comprises black water.
3. A water treatment apparatus according to any one of the preceding claims, wherein the at least one anaerobic chamber comprises a first anaerobic chamber having suspended acetogenic bacteria for treating said waste water.
4. A water treatment apparatus according to claim 3, wherein the at least one
15 anaerobic chamber further comprises a second anaerobic chamber having suspended methanogenic bacteria for further treating said waste water subsequent to treatment of said waste water in said first anaerobic chamber.
5. A water treatment apparatus according to any one of the preceding claims, wherein the at least one aerobic treatment chamber comprises a first aerobic
20 chamber having roots of plant matter with added oxygen.
6. A water treatment apparatus according to any one of the preceding claims, wherein the plurality of chambers further comprises a mixing chamber adapted to receive and mix anaerobically treated waste water with additional untreated waste water.
- 25 7. A water treatment apparatus according to claim 6, wherein the anaerobically treated waste water comprises waste water treated in both the first and second anaerobic chambers.

8. A water treatment apparatus according to claims 6 or 7, wherein the additional untreated waste water comprises grey water.
9. A water treatment apparatus according to any one of claims 4 to 8, wherein the at least one anaerobic chamber further comprises a third anaerobic chamber comprising a filter media having attached bacteria cultures for further treating the waste water subsequent to treatment of the waste water in the first and second anaerobic chambers.
10. A water treatment apparatus according to claim 9, wherein the third anaerobic chamber is arranged to further treat the waste water subsequent to the waste water leaving the mixing chamber, but prior to treatment of the waste water in the first aerobic chamber.
11. A water treatment apparatus according to any one of the preceding claims, wherein the initial untreated waste water comprises a Biochemical Oxygen Demand (BOD) of about 800 to 1200 mg/L, a Chemical Oxygen Demand (COD) of about 900 to 1500 mg/L, and a settleable solids to COD ratio of about 0.40 to 0.60, preferably 0.43.
12. A water treatment apparatus according to any one of the preceding claims, wherein the final treated effluent comprises a BOD of less than 15mg/L, and a COD of less than 50mg/L.
13. A water treatment apparatus according to any one of the preceding claims, wherein the apparatus comprises a modular tank.
14. A water treatment apparatus according to claim 13, wherein the modular tank is adapted to be flat-packed prior to use.
15. A water treatment apparatus according to claim 13 or 14, wherein the volume of the tank is about 1200 L.

16. A method for the treatment of household waste water in a treatment tank comprising a plurality of chambers arranged to allow the waste water to undergo a series of treatments to produce a treated effluent, the method including the steps of:
- 5 allowing the waste water to enter at least one anaerobic chamber in the treatment tank adapted to treat said waste water with anaerobic processes; and
 allowing the waste water to enter at least one aerobic chamber in the treatment tank adapted to treat the anaerobically treated waste water with aerobic processes.
- 10 17. A method according to claim 16, wherein the waste water comprises black water.
18. A method according to any one of claims 16 to 17, wherein the anaerobic processes comprises treating the waste water with suspended acetogenic bacteria.
- 15 19. A method according to any one of claims 16 to 18, wherein the anaerobic processes comprises further treating the waste water with suspended methanogenic bacteria subsequent to treatment with suspended acetogenic bacteria.
- 20 20. A method according to claim 19, wherein the treatment of the waste water with suspended acetogenic bacteria is performed in a first anaerobic chamber, and the treatment of the waste water with suspended methanogenic bacteria is performed in a second anaerobic chamber.
21. A method according to any one claims 16 to 20, wherein the aerobic processes comprises treatment with roots of plant matter and added oxygen.
- 25 22. A method according to any one of claims 16 to 21, further including the step of:

allowing the waste water to enter at least one mixing chamber, the mixing chamber adapted to receive and mix anaerobically treated waste water with additional untreated waste water.

23. A method according to claim 22, wherein the anaerobically treated waste water comprises waste water treated by both suspended methanogenic bacteria
5 and suspended acetogenic bacteria.

24. A method according to claim 22 or 23, wherein the additional untreated waste water comprises grey water.

25. A method according to any one of claims 16 to 24, further including the
10 step of:

allowing the anaerobically treated waste water to enter a third anaerobic chamber, said third anaerobic chamber comprising a filter media having attached bacteria cultures for further anaerobically treating the waste water.

26. A method according to claim 25, wherein the further anaerobic treatment of
15 the waste water is performed subsequent to the waste water entering the mixing chamber, but prior to treatment of the waste water in the first aerobic chamber.

27. A method according to any one of claims 16 to 26, wherein the initial untreated waste water comprises a Biochemical Oxygen Demand (BOD) of about 800 to 1200 mg/L, a Chemical Oxygen Demand (COD) of about 900 to 1500
20 mg/L, and a settleable solids to COD ratio of about 0.40 to 0.60, preferably 0.43.

28. A method according to any one of claims 16 to 27, wherein the final treated effluent comprises a BOD of less than 15mg/L, and a COD of less than 50mg/L.

29. A method according to any of claims 16 to 28, wherein the treatment tank comprises a modular tank.

25 30. A method according to claim 29, wherein the modular tank is adapted to be flat-packed prior to use.

31. A method according to claim 30, wherein the volume of the tank is about 1200 L.