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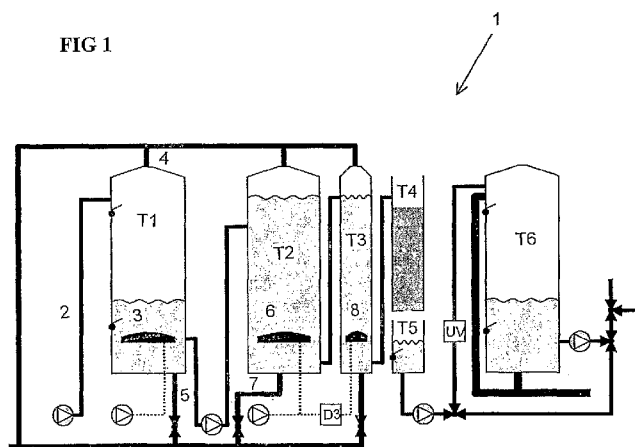
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(54) Title: APPARATUS FOR REMOVING CONTAMINANTS FROM WATER

FIG 1



(57) Abstract: The invention provides a biological waste water treatment process and apparatus that is easy to use and maintain. The apparatus of the invention includes a surge/buffer reservoir including an inlet for receiving waste water to be treated; a reservoir including biomass carriers; a reservoir including an ozone diffuser; a reservoir for collecting treated water including an outlet for dispensing the treated waste water; and conduit connecting the reservoirs to allow for serial flow of waste water undergoing treatment. The apparatus of the invention is particularly well suited to the treatment of commercial or domestic waste water not contaminated by faeces or urine.

APPARATUS FOR REMOVING CONTAMINANTS FROM WATER

FIELD OF THE INVENTION

The invention is directed to a process and apparatus for removing contaminants from waste water. In particular, the invention relates to a process and apparatus for removing contaminants from domestic or commercial grey waste water.

BACKGROUND OF THE INVENTION

Water is becoming scarce in many areas of the world. With little scope for expanding water supply catchments and increasing consumption, the purification of waste water is one way in which existing supplies can be supplemented. The degree of water purification will depend on the extent to which the water is contaminated and the ultimate use of the treated water. Water intended for human or animal consumption and/or contact will require a higher degree of purification than water that is intended for the purpose of toilet flushing, laundry use, garden and agricultural irrigation, and many industrial processes.

"Grey water" is waste water that generally arises from plumbing fixtures not designed to receive human excrement or discharges and is thus not grossly contaminated by faeces or urine. Grey water treatment is of increasing importance due to the large quantities produced by households and industry. According to the invention, grey water includes waste water produced by industrial laundries or waste water generated by commercial car or bus washes, and the like.

Domestically, grey water typically includes bath tub, shower, hand basin, laundry tub, spa bath and washing machine discharges. Grey water characteristics vary between households and depend upon the dynamics of the household, the age and number of occupants, the lifestyle of the occupants and water usage characteristics of the occupants.

Prior art grey water treatment has ranged from simple grey water diversion devices (GDD) to sophisticated treatment systems. Grey water diversion devices do not treat the grey water waste but channel grey water discharge through coarse screens to remove materials which would clog pumps and block pipes. Other methods include primary

treatment which reduces the gross primary pollutant load of the waste water through the settling of solids, flotation, anaerobic digestion, filtration, aerobic digestion, clarification and finally disinfection. Some combinations of these processes have been integrated into systems for on-site treatment of waste water. These systems can be sensitive to failure due to the introduction of biocides into the system and the presence of intractable organic molecules.

One particular problem for any waste water treatment system is its ease of use and maintenance. Any system, especially those intended for use in domestic or light industrial on-site applications, needs to be easy to operate and maintain. For example, it must be readily apparent to the unskilled operator when a service needs to be performed and/or when filters must be changed and chemicals added. If a treatment system is not easy to maintain and operate, the system will fail over time and the confidence of the user of the system will diminish.

Thus, whilst there are a number of processes well recognised for the treatment of waste water, including grey water, there exists a need for additional, or alternative, methods for purifying such water.

SUMMARY OF INVENTION

In one aspect the invention resides in a process for treating waste water comprising the steps of (a) collecting waste water in a collection reservoir; (b) transferring the water from the collection reservoir to a reservoir containing biomass carriers, wherein the water is aerated and the biomass carriers are colonised by aerobic microorganisms to form biofilms; (c) sterilizing the water of step (b) with ozone; and (d) collecting the purified waste water.

The process optionally comprises one or more of (a) passing the water through a filter to remove particles greater than about 300 μm ; (b) aerating and/or mixing the water in the collection reservoir; (c) contacting the water with an adsorbent; (d) disinfecting the water; and (e) removing settled particles from the water undergoing treatment.

Settled particles are removed from the waste water immediately preceding the collection in the collection reservoir; or immediately following treatment in the biomass containing reservoir; or immediately following being contacted with ozone.

The waste water undergoing treatment is optionally passed through a filter which is periodically back washed using water from later in the process, and/or passed through activated carbon and/or past an ultraviolet sterilizer. Excess detergents may be removed to sewer as foam collected from the top of the collection reservoir.

It is desirable although not essential that the process is discontinued periodically, settlement of particles in the waste water undergoing treatment allowed to occur, and any settled particles discharged to waste. Moreover, it is also desirable although not essential that periodically any water that has been purified and stored in the system is resterilised by being brought into contact with the UV sterilizer. Periodically, it is desirable that a small amount of the waste water undergoing treatment is transferred to an earlier stage in the process, so as to help maintain a useful level of viable microorganisms in the reservoirs.

The process of invention is well suited for the treatment of waste water that is commercial or domestic grey water, such as household or commercial car or bus wash waste water. Such waste water can be purified for reuse in the household or in the car or bus wash.

In another aspect, the invention resides in a process for the purification of waste water comprising (a) passing waste water over a filter to remove particles greater than about 300 μm ; (b) transferring the waste water to a first settling tank and removing settled particles; (c) transferring the waste water to a surge/buffer tank and mixing and/or aerating the water; (d) transferring the waste water from the surge/buffer tank to a digester tank containing biomass carriers, wherein the water is aerated and the biomass carriers are colonised by aerobic microorganisms in the waste water and microbial digestion of impurities in the waste water allowed to occur; (e) transferring the waste water to a second settling tank and removing settled particles; (f) transferring the waste water to an ozone contacting tank and sterilizing the waste water with ozone; (g) transferring the waste water to a third settling tank and removing settled particles; (h) contacting the waste water with a carbon adsorbent; (i) disinfecting the waste water with a UV sterilizer; and (j) collecting the purified waste water.

In another aspect, the invention resides in an apparatus for purifying waste water comprising (a) a surge/buffer reservoir including an inlet for receiving waste water to be treated; (b) a reservoir including biomass carriers; (c) a reservoir including an ozone diffuser; (d) a reservoir for collecting treated water including an outlet for dispensing treated waste water; and (e) conduit connecting the reservoirs to allow for serial flow of waste water undergoing treatment. The surge/buffer reservoir may include an air or oxygen diffuser. The apparatus may be portable to the extent that it can be transported to its site of intended use as essentially a single unit.

The apparatus may optionally comprise one or more of (a) a filter capable of screening particles greater than about 300 μm ; (b) a settling reservoir; (c) an adsorbent; and (d) a UV sterilizer. The settling reservoir is located in one or more of the following positions, (a) immediately preceding the surge/buffer reservoir; (b) immediately following the reservoir containing biomass carriers; and (c) immediately following the reservoir containing the ozone diffuser.

Preferably, the adsorbent employed is an activated carbon bed, and the UV sterilizer has an output of 20,000 to 80,000 mW/cm^2 . It is also preferred that the apparatus includes an outlet for removing foam from the top of the surge/buffer reservoir.

The apparatus of the invention may include one or more conduits to allow for removal of waste water and/or sludge from one or more of the reservoirs. Further, one or more conduits may allow for water that is collected post treatment to be recirculated past the UV sterilizer, or for water collected in one reservoir to be transferred to another reservoir that is located earlier in the apparatus.

A single purification unit according to the invention can treat waste water with a flow rate of between about 100 to about 20,000 or about 500 to about 15,000 or about 1,000 to about 10,000 or about 2,000 to about 5,000 litres/day. For example, a unit for a single household will typically be capable of treating between 100 and 2,000 litres/day, whereas a single unit for a housing subdivision or industry might treat between 500 and 20,000 litres/day.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described in a non-limiting manner with respect to the preferred embodiments in which:-

FIG 1 is a schematic of a water purification apparatus according to a preferred embodiment of the invention.

FIG 2 is a schematic of a water purification apparatus according to a preferred embodiment of the invention.

FIG 3 is a graphical representation of the level of BOD₅, COD, SS and turbidity of waste water samples treated according to Example 2.

FIG 4 is a schematic of a water purification apparatus according to a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention is directed to a process and apparatus for the treatment of waste water. Waste water is that water generated in a commercial or domestic setting that is generally not contaminated by faeces or urine, and suitable for reuse in the commercial or domestic setting once purified according to the invention.

For example, households generate a large volume of waste water that has the potential to be recycled for use in irrigating gardens and lawns, or for agricultural purposes including growing vegetables or fruit, or for reuse in the household including flushing toilets and the like.

Grey water accounts for the majority of waste water produced by each household and it is therefore desirable to purify this water for further use in a manner that protects public health and meets health guidelines. Grey water generally contains variable quantities of inorganics (e.g. dissolved salts such as phosphates, nitrates, etc), organics (e.g. oils,

greases, soap, toothpaste, shampoo/conditioner, hair dyes, surfactants and cleaning chemicals), physical impurities (e.g. dirt, food, sand, lint, hair, blood, urine, faeces etc) and micro-organisms (e.g. bacteria, viruses, protozoa etc) which arise from household and personal hygiene practices.

There are also numerous commercial facilities that produce waste water that has the potential to be recycled for reuse. For example, commercial facilities, such as car or bus washes, generate a large amount of waste water that could be recycled and reused.

Taking the above factors into account, the invention describes an apparatus and process for treating waste water effluent, especially grey water, rendering it suitable for reuse. Waste water treated according to the invention has a low level of solids, bacteria and/or turbidity. The skilled addressee will appreciate that the invention could be employed in either a domestic or a commercial setting and whilst particularly suited to the treatment of grey water can also be employed in the treatment of other types of waste water.

The process of the invention is essentially a continuous flow process, as opposed to a batch type process. Accordingly, varying the flow rate through the process or apparatus varies the amount of waste water treated.

According to the invention, a single purification unit can treat waste water at the rate of between about 200 to about 20,000 litres/day, or about 500 to about 15,000 litres/day, or about 1,000 to about 10,000 litres/day. The invention is equally effective where a single unit is employed, or where a number of smaller units are connected in parallel. The size of a single unit for household use might be, for example, one that can treat up to about 1,000 litres/day, whereas for a commercial car or bus wash, for example, a capacity of up to 20,000 litres/day or larger may be required. The skilled addressee will appreciate that the use of multiple units of the same or of different sizes in parallel can be employed to achieve the desired flow rate/day.

The process and apparatus of the invention is well suited to treating waste water for subsequent use in subterranean or subsurface irrigation for gardens, lawns or for agriculture. Waste water purified according to the invention may also be employed for surface irrigation, depending upon the specific regulatory requirements of different jurisdictions.

The invention seeks to provide a waste water treatment system that is easy to use and maintain, as systems that are difficult to use and maintain tend to malfunction leading to a potential health and environmental hazard, and unpleasant odours. This is especially so in the domestic setting where systems are often maintained by the layperson. Accordingly, the invention seeks to provide a process for purifying waste water, including domestic grey water, including a unique combination of process steps that is robust, simple to use, and maintain. The invention also seeks to provide an apparatus for use in combination with the process.

According to a preferred embodiment and with reference to Figure 1, waste water enters treatment system 1 at the top of a surge/buffer tank T1 via inlet 2 and is aerated by air pumped through a membrane diffuser 3 to mix water from different sources and begin the aerobic digestion process. Excess detergents are removed to sewer as foam collected from 4 at the top of the tank T1. Dense particles settle at the bottom of the tank T1 and are periodically dumped to sewer via 5.

Water is transferred from the surge buffer tank T1 to the top of an aerobic digester tank T2. The digester tank contains biomass carriers suspended in the water contained therein. The skilled addressee could determine without inventive faculty biomass carriers suitable for use in the invention. The water in tank T2 is oxygenated by pumping air through a membrane diffuser 6 in the base of tank T2. Periodically, the treatment process is paused, aeration is ceased and after a settlement period, particulate matter is dumped from the bottom of the tank to sewer, or transferred to tank T1, via line 7.

Water then travels from digester tank T2 to the ozone contactor T3. Preferably, the water leaves the aerobic digester towards the top of the tank, and enters towards the bottom, and the ozone contactor receives water towards the bottom of the tank, with the water exiting towards the top. Ozone is bubbled up through the contactor T3 from a fine pore diffuser 8 at the bottom of the tank. The ozone sterilizes the water and oxidises organic compounds remaining after the microbiological digestion process.

Water travels from the ozone contactor tank T3 to the top of a column of activated carbon T4, which adsorbs organic compounds. Water collected from the bottom of T5 is pumped through a UV sterilizer and into a storage tank T6. Optionally, a settlement tank can be

employed prior to tank T1 and/or between one or more of tanks T1 to T6. The skilled addressee can readily determine suitable UV sterilisers and a necessary dose of UV radiation to sterilise the waste water undergoing treatment. The method of the invention may optionally include one or more polishing filters.

In an alternative embodiment depicted in Figure 2, grey water is pumped into the treatment system 10 from a collection pit (not shown). The grey water passes over a wire screen 20, preferably a parabolic wedge wire screen, to remove hair, lint and other particles larger than about 300 μm , and preferably removing particles larger than 200 μm . The screen 20 is washed periodically using treated water from later in the process. In this way, hair and lint is regularly flushed to sewer.

The screened water passes into a settlement chamber S1 under gravity where dense particles, such as sand, can accumulate in the bottom. Periodically a valve V2 at the base of this chamber is opened so that the particulate material is flushed to sewer by the body of water held in the chamber.

The particulate free grey water travels over a weir 22 from the settlement chamber into the top of a surge/buffer tank T1. The water is aerated by pumping air through pump P2 to a membrane diffuser 26 at the base of the tank T1. This mixes the water from different sources and starts the aerobic digestion process. Excess detergents are removed to sewer as foam collected from the top of this tank. The volume of water in this tank varies, rising to its maximum level by addition of more water from the transfer pit (not shown) and falling to its minimum as water is pumped into the rest of the process. In this way T1 provides a buffer of blended water for the rest of the process. Periodically aeration is stopped in T1, the particulate material allowed to settle, and a small volume from the water at the bottom of the tank dumped to sewer via valve V1.

Water is transferred from the lower part of the surge/buffer tank T1 to the lower part of an aerobic digester tank T2 at a flow rate determined by a transfer pump P1. This tank is kept at a near constant level by water being pumped in at regular intervals and an exit weir 28 near the top of the tank. This body of water contains floating biomass carriers. There are many suitable carriers available. These carriers are fluidised, and the water oxygenated, by pumping air through pump P3 to a diffuser 30 in the base of the tank T2. Aerobic microorganisms colonise the biomass carriers and form stable biofilms which

retain large numbers of microorganisms on the surface of the beads and protect them from the effects of most biocides. Periodically the treatment process is paused, aeration ceased and after a period of settlement a valve V3 is opened in the base of the tank T2 so that the particulate matter, mostly composed of microorganisms not attached to the carriers, can be transferred, by the body of water above, to the bottom of the surge/buffer tank T1. This transfer of adapted organisms both assists in the aerobic digestion process and in the maintenance of micronutrients in the treatment system as a whole.

Water travels from the top of the digester tank T2 to the top of a second settlement chamber S2 under gravity. This chamber allows particulate matter, mostly microorganisms, carried over from the digester, to settle. Periodically a valve V4 is opened in the base of the chamber S2 so that the particulate matter is transferred, by the body of water above, to the bottom of the surge/buffer tank T1. This transfer of adapted organisms again assists in the aerobic digestion process and in the maintenance of micronutrients in the treatment system as a whole.

Clarified water from the top of the second settlement chamber S2 passes into the bottom of a sterilising tank T3 under gravity. Ozone, generated by passing air from P6 through ozone generator O3, is bubbled up through the sterilizing tank T3 from a fine pore diffuser 32 at the bottom. The ozone sterilises the water and oxidises organic compounds remaining after the microbiological digestion process. Periodically the treatment process is paused, ozonation ceased and, after a period of settlement, a valve V5 is opened in the base of the tank T3 so that the particulate matter is dumped to sewer, or transferred to T1, by the body of water above.

Water travels from the top of the sterilizer tank T3 to the top of a third settlement chamber S3 under gravity. This chamber allows particulate matter generated by the ozonation process to settle. Periodically a valve V6 is opened in the base of the chamber S3 so that the particulate matter is transferred, by the body of water above, to the bottom of the surge/buffer tank T1. This transfer of material also assists in the maintenance of micronutrients in the treatment system as a whole. During transport through the settlement tank S3 the ozone in the water decomposes back into oxygen.

The clarified water spills onto the top of a bed of granulated activated carbon T4. As the water trickles past the activated carbon, organic compounds are adsorbed onto the highly

reticulated surface of the carbon. Over time the activated carbon becomes colonised with microorganisms which aid in the oxidation of organic compounds and the regeneration of the adsorption surfaces on the carbon. This biologically activated carbon has an extended period of activity.

Water collected from the bottom of the biologically activated carbon bed is pumped by P4 from collection vessel T5 through a UV steriliser and into the top of a storage tank T6. Periodically the transfer of water by P4 is paused and the contents of the clean water tank T6 recirculated through the UV steriliser, using the same pump P5 used to supply the water to the end user. This maintains the sterility of the water held in the storage tank. The UV steriliser is of the correct size to supply $>40,000\text{mW/cm}^2$ at the flow rate generated by the supply pump.

Figure 4 depicts a further preferred embodiment of the invention. T1 to T6 are as specified in Figures 1 and 2. Waste water is collected in a surge/buffer tank T1. Water in the tank T1 is aerated by diffuser 54 at the bottom of column 56. Foam is removed from the top of column 56 by pump 52 and sent to waste. Water subsequently passes from the bottom of T1 to the bottom of digester tank T2 via pump 58. Digester tank T2, containing biomass carriers is aerated by diffuser 60, and after a period of time the water undergoing treatment is gravity fed from the top of T2 to the bottom of ozone contacting tank T3 via connecting pipe 62. After sterilization by ozone delivered by diffuser 64, the waste water undergoing treatment is transferred from the top of T3 to a settling tank S1, where settled particles are removed. In fact, settled particles can be dumped to sewer from any one of tanks T1, T2 T3 or S1 via pipe 66. Moreover, waste water from a tank later in the process can be transferred to a tank earlier in the process via pipe 66 employing a series of valves on pipe 66. Such transfers are suggested by arrows A and B. Preferably, waste water is transferred from the digester tank to the buffer tank, so as to maintain a useful level of microorganism activity.

From settling tank S1 waste water undergoing treatment is transferred to a bed of activated carbon T4. S1 is advantageous in removing unwanted impurities prior to treatment by the activated carbon. Water collected in T5 is sterilized again under UV before being reused, or collected in tank T6 for use as desired. Treated waste water in tank T6 can be resterilised under UV as suggested by arrow D.

The invention will now be described with reference to a number of examples. The examples demonstrate the utility of the invention in purification of waste water and in particular waste water containing surfactant, biological and/or fat impurities, such as household or vehicle wash grey water. It will be understood that particular embodiments described herein are shown by way of illustration and not as limitations of the invention. The principal features of this invention can be employed in various embodiments without departing from the scope of the invention. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, numerous equivalents to the specific procedures described herein. Such equivalents are considered to be within the scope of this invention and are covered by the claims.

Grey water is typically not homogenous. For example, household grey water pH is often anywhere between 5 and 11, and surfactant load can range from low to very high. The lack of homogeneity adds greatly to the complexity of any purification system, and often makes purification difficult, if not impossible. The present inventors have however surprisingly found that grey water can be efficiently and reliably converted into clear, clean and reusable water using a novel combination of processes. As discussed in greater detail above, the method and apparatus of the invention incorporates a combined filtration and settlement pre-treatment step followed by aerobic digestion, ozonation, filtration through biologically activated carbon and final disinfection with ultraviolet light. The invention produces high quality, reusable water, rapidly and efficiently from heterogeneous grey water. Moreover, the invention offers advantages with respect to ease of use and maintenance.

Preferably, treated water has a BOD₅ of less than 10 mg/L, a turbidity of less than 10 NTU and less than 10 thermotolerant coliforms per 100 mL.

EXPERIMENTAL RESULTS

Example 1

A small scale prototype of the invention treated water over a 9 month period from a variety of domestic and light industrial sources at flow rates of between 1 mL/min and 6 mL/min. The treatment process included aerobic digestion in a pair of tanks containing biomass carriers, ozonation in a simple column contactor, trickle filtration through a bed of biologically activated carbon and sterilisation by ultraviolet irradiation.

The aerobic digester consisted of two cylindrical vessels into which air was introduced through medium pore diffusers. Dirty foam formed on the top of these cylinders and the outlets was sent to waste. The volume of water lost varied considerably dependant on the introduced air flow and the detergent content of the water. Biomass carriers were used in the digesters to support the growth of organisms adapted to consume nutrients found in grey water.

Ozonation of the water after microbial digestion was intended to serve the dual function of oxidising material that could not be broken down by the microorganisms and disinfecting the water to reduce the number of live organisms carried through the process. Water was introduced into the top of a column through which ozonated air, introduced through a fine SS mesh diffuser, bubbled up, and left from the bottom. On occasion a dirty foam also formed which was directed to waste. The spent gasses from this column were directed into a common waste from the aerobic digester. The foam from the digester reacted with residual ozone from the contactor and considerably reduced contamination of the test area with ozone.

The activated carbon filter was constructed in a cylindrical vessel and arranged so that water leaving the ozone contactor flowed under gravity onto the top of the bed and trickled down to the outlet. It was expected that the carbon would operate in three modes. The first was adsorption of organic molecules to the surface of the carbon. The second was as a support media for microorganisms, which would consume the organic compounds. Finally, the filter bed could act as a depth filter removing particulate material carried through from the digester and the ozone contactor.

The ultraviolet steriliser was installed so that water leaving the activated carbon travelled up through the UV device and out into a collection vessel. It was highly desirable that the water had low turbidity and UV absorbance prior to entering the steriliser and that the steriliser produced sufficient radiation to ensure sterilisation.

Samples taken generally had BOD₅ of 2 mg/L or less, no faecal coliforms and turbidity of less than 5 NTU. The system required little maintenance other than removal of accumulated fine grey particulate material every 3 months.

Table 1 provides a measurement of the BOD₅ (mg/L) and suspended solids (mg/L) concentrations of seven samples of grey water before and after treatment according to the process of the invention.

Date of Sample	Source	BOD ₅ , mg/L	Suspended Solids, mg/L
29/01/08	Grey Water	44	30
	Reuse	4	<2
22/01/08	Grey Water	52	26
	Reuse	3	<2
19/11/08	Grey Water	37	28
	Reuse	<2	<2
26/06/07	Grey Water	120	-
	Reuse	<2	-
21/06/07	Grey Water	36	-
	Reuse	2	-
11/06/07	Grey Water	21	-
	Reuse	<2	-
31/05/07	Grey Water	27	-
	Reuse	<2	-

TABLE 1

Example 2

A prototype water treatment system capable of treating 1500 litres of grey water per day was constructed. The performance of this system was tested over a one week period using waste water from a car wash facility. The system successfully treated over 4000 litres of water to a standard suitable for reuse. The prototype was based upon the embodiment depicted in Figure 1.

With reference to Figure 1, waste water is transferred into the buffer tank to maintain the water level between the low level switch at about 115 L and the high level switch at about 475 L. This water was aerated at 50 LPM through a 9" diameter PTFE coated membrane diffuser. Water was transferred into the digester tank at 1 LPM through a pump whenever there was sufficient water in the buffer tank. The digester tank contained ~150 L of biomass carriers and was aerated at 60 LPM through a 9" diameter PTFE coated

membrane diffuser. As the digester tank filled above 475 L water flowed under gravity into the ozone contact column where ozonated air was introduced through a medium pore silica diffuser at 2 LPM. As the ozone column filled above 30 L water flowed under gravity into a column of activated carbon with a surface area of 434 cm^2 , a bed height of 144.5 cm (a volume of $\sim 62.7 \text{ L}$). Water draining through the column was lifted through a ultra violet unit containing a composite 180/254nm lamp into the storage tank by a 40 watt pond pump.

For this experiment the raw waste water from the car wash facility was first filtered through 100L of pool sand to remove coarse particulate. The water was then pumped into the buffer tank at 9.6 LPM, dosed with 10% hydrogen peroxide at 10 mL per minute ($\sim 100 \text{ mg/L H}_2\text{O}_2$ final) and passed through a 25 Watt UV steriliser (capable of dosing the water with up to 150 mW/cm^2 @254 nm). This pre-treatment was introduced as an additional experiment to investigate the potential of an Advanced Oxidation Process (AOP) to decrease non-biodegradable oxygen demand (COD).

The test was performed inside an unheated shed during a period when daily temperatures ranged from an average of 4.4°C at night to an average of 14.5°C during the day. The data collected is in Table 2 below, wherein SS is suspended solids, BAC is Biologically Activated Carbon, BOD_5 is 5 day Biological Oxygen Demand, and COD is Chemical Oxygen Demand.

Time	Date	Sample	Turbidity	SS	COD	BOD ₅	Faecal Coliforms	Temp °C	pH	Daily Output, L
16:20	17/06/2008	Influent	-	99	300	82	-	-	-	
10:10	18/06/2008	Influent	96.0				-	11.3	5.1	15211.9
12:52	18/06/2008	Treated	3.5	-	-	-	-	11.8	5.6	
13:03	18/06/2008	Ex BAC	2.1	-	-	-	-	11.3	5.5	15291.5
15:35	18/06/2008	Influent	86.0	75	350	97	<2	11.8	5.2	
15:40	18/06/2008	Treated	2.6	-	-	-	-	12.6	5.5	15429.2
11:05	19/06/2008	Treated	3.5	5	20	3	<1	11.7	5.5	1125.4
11:20	19/06/2008	Influent	187.7	75	350	88	-	11.5	4.5	
13:10	19/06/2008	Treated	3.8	-	-	-	-	12	5.3	16482.3
9:12	20/06/2008	Influent	79.0	82	370	84	-	11.8	4.8	1261.2
9:20	20/06/2008	Ex BAC	5.4	-	-	-	-	12.1	5.2	
9:30	20/06/2008	Foam Over	-	2700	17000	37	-	-	-	
11:30	20/06/2008	Treated	6.7	5	27	4	<1	12.9	5.2	
14:15	20/06/2008	Pre BAC	109.0	71	270	<2	-	12.3	4.7	17952.9
10:40	21/06/2008	-	-	-	-	-	-	-	-	1007.4
9:55	23/06/2008	Ex BAC	4.3	3	8	2	-	10.8	5.4	18913.3
10:20	23/06/2008	Treated	4.9	6	23	3	<1	8.4	5.3	
11:20	23/06/2008	Influent	63.0	62	310	76	-	10.4	5.2	202.8
9:40	24/06/2008	Pre BAC	88.3	130	290	<2	-	9.1	4.2	
9:50	24/06/2008	Treated	7.0	5	26	<2	-	9.8	5.2	420
									Total	4219.6
										Influent >6000 L

TABLE 2

Results for the experiment are summarised in the following table.

Sample	Mean						
	Turbidity	SS	COD	BOD ₅	Faecal Coliforms	Temperature °C	pH
Influent	102.3	78.6	336	85.4	<2	11.4	4.96
Pre BAC	98.7	100.5	280	<2	-	10.7	4.45
Ex BAC	3.2	3	2	2	-	11.4	5.30
Treated	4.6	5.25	24	3	<1	11.3	5.37

TABLE 3

The influent water was moderately fouled with colloids, mean turbidity 102.3 NTU (Nephelometric Turbidity Units) and mean suspended solids 78.6 mg/L. It contained a moderate amount of oxidisable chemicals characterised by a COD of 336 mg/L. A sub-set of these were biologically degradable as characterised by a BOD₅ of 85.4 mg/L. The water was acid, pH 4.96, and contained no faecal coliforms.

The “Pre BAC” samples show what the early treatment steps were able to remove. There was little change to the turbidity and suspended solids. This was surprising as a considerable amount of highly contaminated water left the buffer tank in “foam over”. A sample of “foam over” liquid had a COD of 17,000 mg/L, a BOD₅ of 37 mg/L and suspended solids of 2,700 mg/L. There was, however, essentially complete removal of the biodegradable material. This is quite remarkable given the presence of biocides in the influent water, its low pH and the low temperature of the water. There was, however, little change in the level of non-biodegradable oxidisable substances.

The “Ex BAC” sample showed that the column of activated carbon performed the function of a particle filter and a chemical absorber. With suspended solids and turbidity both dropping from around 100 to around 3. The flow rate through the column decreased sharply after ~3,000 litres of treated water had passed through suggesting that most of the interstitial spaces had been filled. The adsorption capacity of the carbon was not reached as it continued to decrease the COD of the water from around 280 to around 2 throughout the experiment. The activated carbon was also able to increase the pH from 4.45 to 5.30.

The treated samples were completely free from faecal coliforms and had turbidity, suspended solids and BOD₅ which were essentially unchanged from those collected at the exit of the BAC column. The COD increased from around 2 to around 24 as a result of passage through the dual wavelength UV steriliser. The results are depicted graphically in Figure 3.

The first step used in this example, was introduced as an addition to the base process to examine the potential of the method to deal with a light industrial wastewater. The step involved dosing the waste water with hydrogen peroxide and irradiating it with ultraviolet light. This is an example of an advanced oxidation process (AOP) in which the oxidative capacity of a parent compound, in this case hydrogen peroxide, is modified, in this case by ultraviolet light, to make oxidation-reduction reactions more rapid or complete. These processes have the ability to completely mineralise oxidisable substances to carbon dioxide and water when each agent is dosed correctly. It is often uneconomical to take the reactions to this end point but it is often most economical to pre-treat difficult waste products so that they are then able to be degraded completely by microorganisms. In this example the quantity of COD in the waste water was unknown before testing began so arbitrary values for hydrogen peroxide dose, 100 mg/L, and UV dose, ~150 mW/cm² were chosen. Water test results showed that the initial COD level was >320 mg/L of which approximately a quarter, >80 mg/L, was biodegradable. After the AOP and passage through the aerobic digester the biodegradable material was reduced to the level of detection, 2 mg/L, but the COD level was essentially unchanged, 280 mg/L.

These results suggest that the AOP was ineffective at the doses chosen. Literature suggests that hydrogen peroxide should be dosed with at least twice the level of COD for optimal degradation. However, there should have been sufficient oxidant present to see a detectable level of breakdown. Literature also suggests that the UV dose should be between 1000 mW/cm² and 4000 mW/cm² for optimal activity. This was difficult to obtain when the water to be irradiated is turbid, >100 NTU. A pre-treatment step which raises the pH to around neutral and causes the suspended material to settle quickly leaving a supernatant with low turbidity could alternatively be employed. Between 1.5 gms/L and 2.0 gms/L of light magnesium carbonate, stirred for 45 min and then leave to settle for >10 hours, could be one way to achieve this.

The car wash water had some challenging properties for treatment in a process with several biological elements. The first is the presence of biocides as evidenced by the absence of coliforms in the feed. The second is the low pH which is outside the optimum for most autotrophic micro organisms. The third is the high COD to BOD₅ ratio which suggests the presence of large amounts of non-biodegradable organic compounds. It was, therefore, quite surprising to see that the aerobic digestion and ozonation steps removed essentially all the BOD.

The digester tank T2 can have the aeration turned off periodically so that settlement can occur and “sludge” can be dumped to sewer or the flow of water through the digester can be reversed from the top to bottom direction used in this example. In this example, the water leaving the ozone contactor was largely free of BOD but had both a high level of COD, 280 mg/L, and turbidity, 98.7 NTU. This water entered the top of the BAC column at 1 LPM and trickled down into an open collection vessel. The column was able to pass water at this flow rate for about 3000 L before it became blocked by particulate. The activated carbon still continued to pass water at a reduced flow rate and water leaving the column consistently had a very low level of COD, 2 mg/L, and turbidity, 3.2 NTU. It is therefore highly preferred that particulate material is removed prior to entering the BAC column, by for example a settlement vessel. In a domestic environment it is desirable for the BAC to have a long active period. In municipal situations BAC systems can treat >40,000 volumes of water which would equate to 5 years water treatment with the current BAC column.

Water leaving the BAC column contains microorganisms which are inactivated by irradiation with ultraviolet light prior to storage of the water. UV sterilisation is performed by passing the water through a chamber containing a low pressure mercury discharge lamp. The water is separated from the body of the lamp by a hard quartz sleeve which passes light at around 254 nm in wavelength. In this example, the UV steriliser is capable of dosing water with 38 mWs/cm² at a flow rate of 15 LPM. The current test included a UV emitter and sleeve which could pass radiation at 180 nm as well as 254 nm. The lower wavelength light is both more destructive to nucleic acids and capable of breaking down organic compounds. Test results showed the absence of coliforms, confirming the performance of the UV steriliser, but an

increase in the level of BOD. The increased BOD is most likely to have come from the breakdown of non-biodegradable compounds by the 180 nm light.

The UV steriliser is also used to maintain the sterility of the stored treated water. The test system performed this function using only one UV steriliser, periodically pausing the treatment process and passing the treated water through the UV steriliser using the re-use pump.

All of the processes and apparatus disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the processes of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the processes and in the steps or in the sequence of steps of the process described herein without departing from the concept, spirit and scope of the invention. More specifically, it will be apparent that certain agents which are both chemically and physiologically related may be substituted for the agents described herein while the same or similar results would be achieved. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the invention as defined by the appended claims.

CLAIMS

The claims defining the invention are as follows:

1. A process for purifying waste water comprising the following steps:
 - (a) collecting waste water in a collection reservoir;
 - (b) transferring the water from the collection reservoir to a reservoir containing biomass carriers, wherein the water is aerated and the biomass carriers are colonised by aerobic microorganisms to form biofilms;
 - (c) sterilizing the water of step (b) with ozone; and
 - (d) collecting the purified waste water.
2. The process of claim 1, wherein the process further comprises one or more of the following steps:
 - (a) passing the water through a filter to remove particles greater than about 300 μm ;
 - (b) aerating and/or mixing the water in the collection reservoir;
 - (c) contacting the water with an adsorbent;
 - (d) disinfecting the water; and
 - (e) removing settled particles from the water undergoing treatment.
3. The process of claim 2, wherein the settled particles are removed from the waste water at one or more of the following points:
 - (a) immediately preceding the collection in the collection reservoir;
 - (b) immediately following treatment in the biomass containing reservoir; and
 - (c) immediately following being contacted with ozone.
4. The process of claim 3, wherein excess detergents are removed to sewer as foam collected from the top of the collection reservoir.
5. The process of claim 4, wherein contacting the water with adsorbent involves passing the water through activated carbon.

6. The process of claim 5, wherein disinfecting the water involves passing the water past an ultraviolet sterilizer.
7. The process of claim 6, wherein the water is passed through a filter and the filter is periodically back washed using water from later in the process.
8. The process of claim 7, wherein the process is discontinued periodically, settlement of particles in the waste water undergoing treatment allowed to occur, and any settled particles discharged to waste.
9. The process of claim 8, wherein the process is discontinued periodically, and any water that has been purified and stored in the system is resterilised by being brought into contact with the UV sterilizer.
10. The process of claim 9, wherein water undergoing treatment is transferred to an earlier stage in the process, and wherein the transferred water may contain viable microorganisms employed in the treatment process.
11. The process of claim 10, wherein the waste water is commercial or domestic grey water.
12. The process of claim 10, wherein the waste water is commercial car or bus wash waste water, and the waste water is purified for reuse in the car or bus wash.
13. A process for the purification of waste water comprising the following:
 - (a) passing waste water over a filter to remove particles greater than about 300 μm ;
 - (b) transferring the waste water to a first settling tank and removing settled particles;
 - (c) transferring the waste water to a surge/buffer tank and mixing and/or aerating the water;
 - (d) transferring the waste water from the surge/buffer tank to a digester tank containing biomass carriers, wherein the water is aerated and the biomass carriers are colonised by aerobic microorganisms in the waste water and microbial digestion of impurities in the waste water allowed to occur;

- (e) transferring the waste water to a second settling tank and removing settled particles;
 - (f) transferring the waste water to an ozone contacting tank and sterilizing the waste water with ozone;
 - (g) transferring the waste water to a third settling tank and removing settled particles;
 - (h) contacting the waste water with a carbon adsorbent;
 - (i) disinfecting the waste water with a UV sterilizer; and
 - (j) collecting the purified waste water.
14. An apparatus for purifying waste water comprising the following:
- (a) a surge/buffer reservoir including an inlet for receiving waste water to be treated;
 - (b) a reservoir including biomass carriers;
 - (c) a reservoir including an ozone diffuser;
 - (d) a reservoir for collecting treated water including an outlet for dispensing treated waste water; and
 - (e) conduit connecting the reservoirs to allow for serial flow of waste water undergoing treatment.
15. The apparatus of claim 14, further comprising one or more of the following:
- (a) a filter capable of screening particles greater than about 300 μm ;
 - (b) a settling reservoir;
 - (c) an adsorbent; and
 - (d) a UV sterilizer.
16. The apparatus of claim 15, wherein the settling reservoir is located in one or more of the following positions:
- (a) immediately preceding the surge/buffer reservoir;
 - (b) immediately following the reservoir containing biomass carriers; and
 - (c) immediately following the reservoir containing the ozone diffuser.
17. The apparatus of claim 16, further comprising an outlet for removing foam from the top of the surge/buffer reservoir.

18. The apparatus of claim 17, wherein the adsorbent is an activated carbon bed.
19. The apparatus of claim 18, wherein the UV sterilizer has an output of 20,000 to 80,000 mW/cm².
20. The apparatus of claim 19, further including one or more conduits to allow for removal of waste water and/or sludge from one or more of the reservoirs.
21. The apparatus of claim 20, further including one or more conduits to allow for water that is collected after treatment to be recirculated past the UV sterilizer.
22. The apparatus of claim 21, further comprising one or more conduits to allow for water collected in one reservoir to be transferred to another reservoir that is located earlier in the apparatus.
23. The apparatus of claim 22, which is capable of treating between 500 and 10,000 litres/day.
24. The apparatus of claim 22, which is capable of treating between 100 and 2,000 litres/day.
25. The apparatus of claim 23, wherein the surge/buffer reservoir includes an air or oxygen diffuser.
26. The apparatus of claim 25, which is portable to the extent that it can be transported to its site of intended use as essentially a single unit.

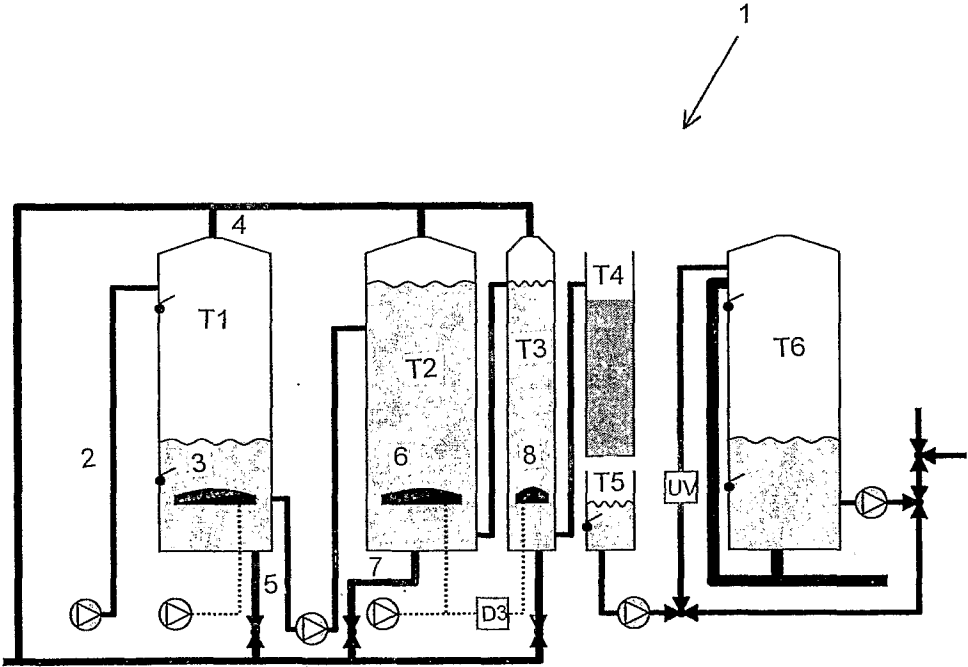


FIG 1

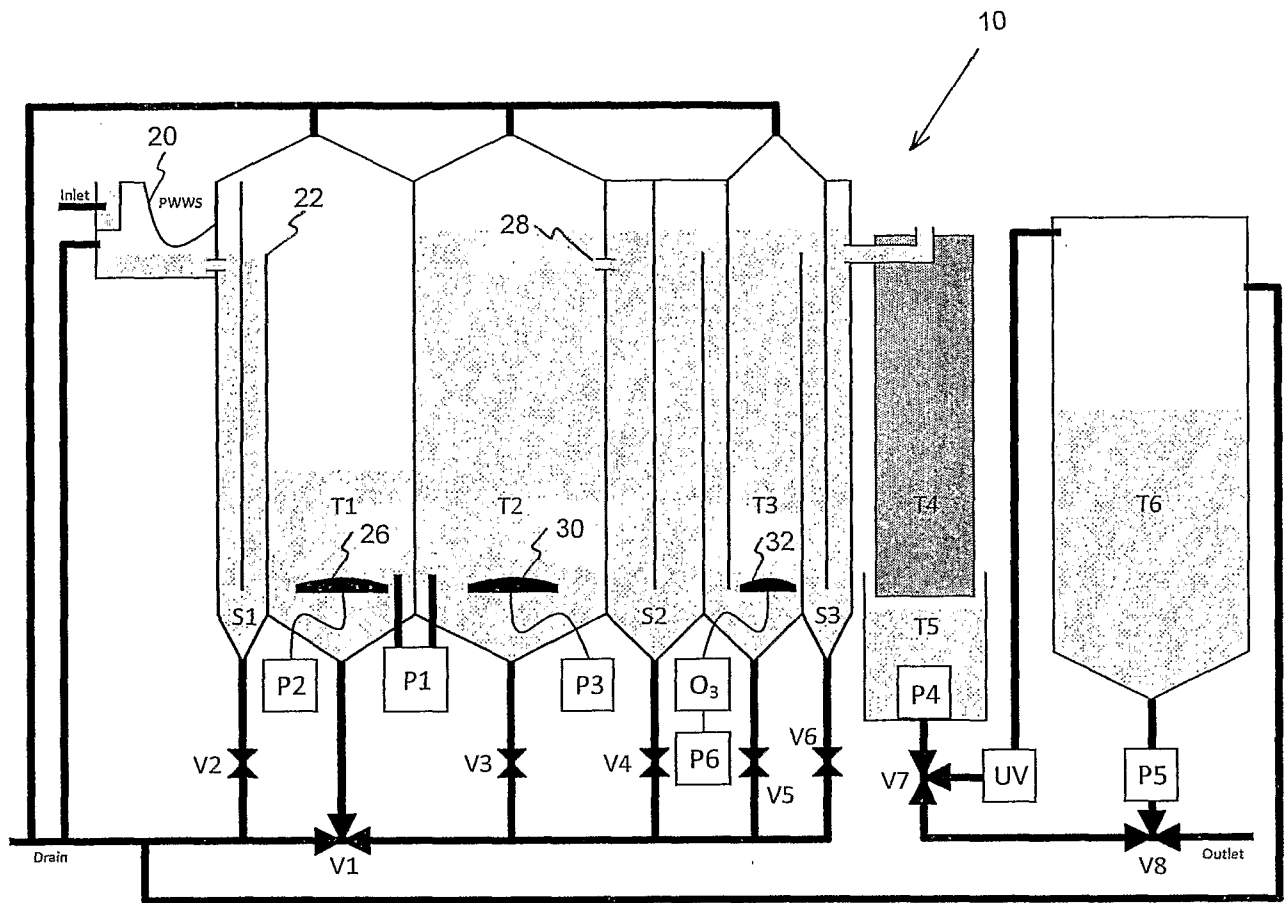


FIG 2

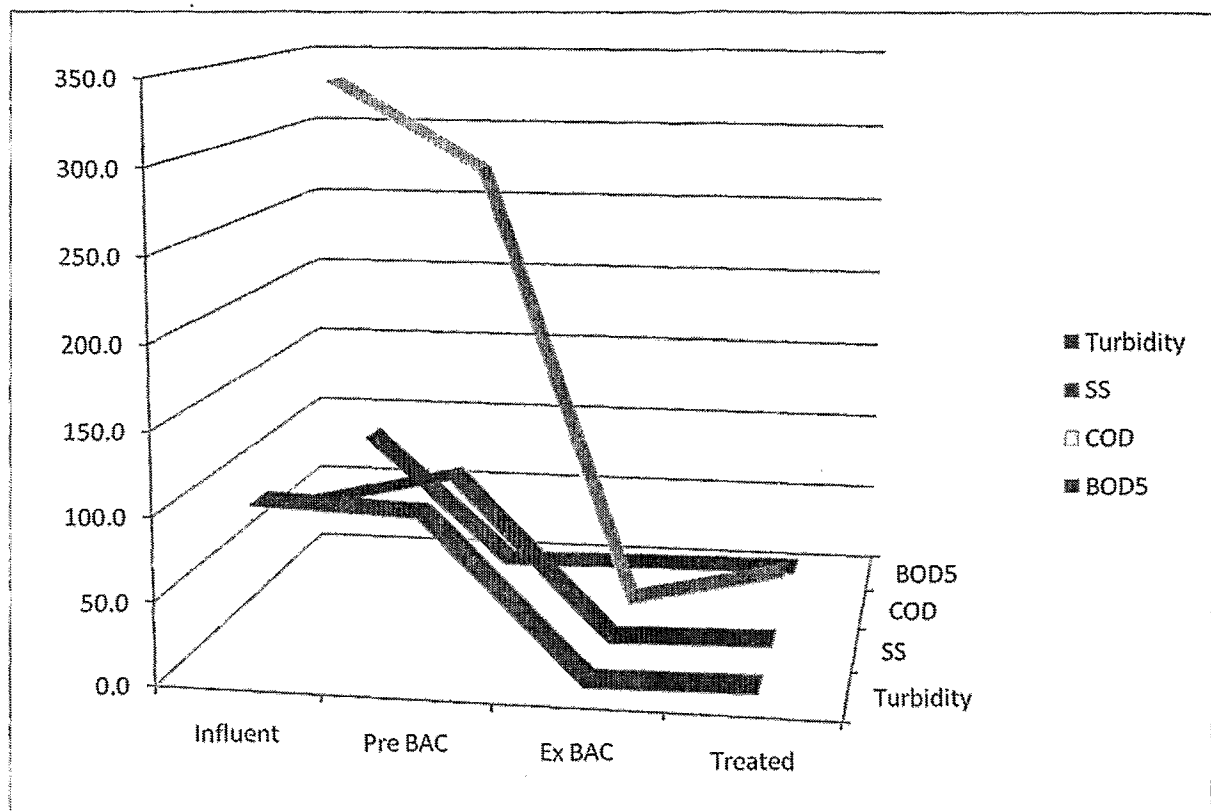


FIG 3

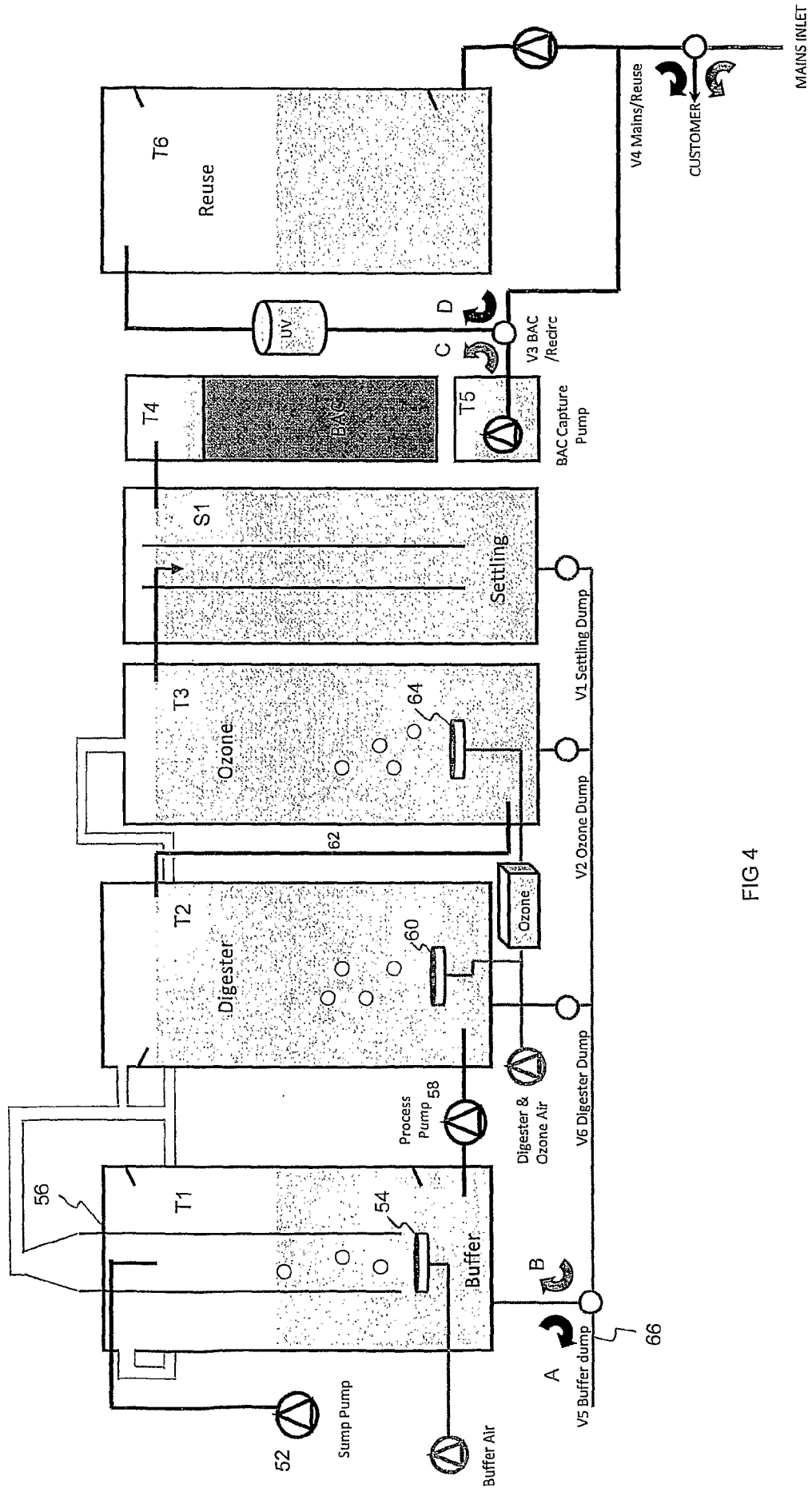


FIG 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/000553

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C02F 9/00 (2006.01)

C02F 3/12 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC & WPI: IPC & EC C02F & Keywords (Biomass, ozone, ultraviolet, charcoal, aerobic, filter, sterilisation) and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2003/0015469 A1 (HEDENLAND et al) 23 Jan 2003 Abstract, claims, paragraphs 15-19 As above	1-6, 14-26 7-12
X Y	JP 2003-236584 (ATAKA KOGYO KK) 26 August 2003 Abstract and Figure 1 & 2 and translation from http://www.ipdl.inpit.go.jp/homepg_e.ipdl As above	1-6, 13-26 7-12
X	US 4337152 (LYNCH) 29 June 1982 Figure 1, Column 3, 7 and 9	1-3, 14-16
X	US 4256574 (BHARGAVA) 17 March 1981 Figure 1, Column 5 & 7	1-3, 14-16

☒ Further documents are listed in the continuation of Box C

☒ See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
17 June 2009

Date of mailing of the international search report

02 JUL 2009

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/000553

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6398959 B1 (TERAN et al) 4 June 2002 See column 15, line 14-21	7-12
A	US 4548716 (BOEVE) 22 October 1985 See whole document	
A	Derwent Abstract Accession No 2005-740439, Class D15, JP2005305222 (KANKYO SYSTEM KIAHATSU KK) 04 November 2005 See whole abstract	
A	Derwent Abstract Accession No 2006-247764, Class D15, JP 2006088116 (SAWADA Y) 06 April 2006 See whole abstract	
Note: For the Y indications, either of US 2003/0015469 or JP 2003-236584 can be combined with US 6398959 to arrive at the invention of claim 7.		

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2009/000553

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member			
US	2003015469	NONE				
JP	2003236584	NONE				
US	4337152	NONE				
US	4256574	CA 1141044 ZA 8005649	EP 0025589	ES 8106680		
US	6398959	CA 2381392 US 6395174	US 6039874 US 6554998	US 6193889 US 6599424		
US	4548716	NONE				
JP	2005305222	NONE				
JP	2006088116	NONE				
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.						
END OF ANNEX						