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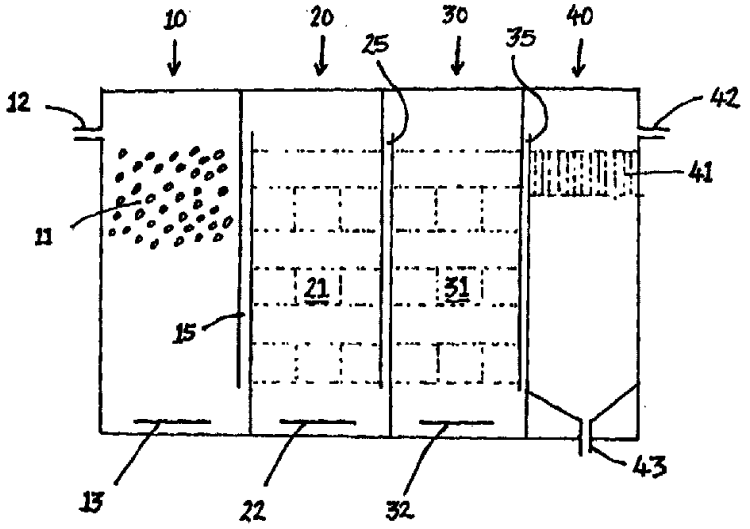
(54) Title: WASTEWATER TREATMENT



(57) Abstract

A wastewater treatment system comprises a fixed bed aeration zone (20, 30) and, upstream of the aeration zone, a moving bed biofilm reactor zone (10). Typically, the reactor zone comprises a buoyant medium (11) and a forced oxygen supply (13).

WASTEWATER TREATMENT

Field of the Invention

This invention relates to the treatment of wastewater, and to apparatus for use in such treatment.

Background of the Invention

It is standard practice to treat wastewater by passage through a sequence of aeration zones, comprising one submerged fixed bed zone at least, for biological treatment, into a settlement zone. For example, there may be 3 or 4 separate compartments each provided with a fixed film bed. A disadvantage of a fixed medium is that only relatively low specific area (e.g. less than 150 m^2/m^3) may be used in the first zones, due to vigorous biological growth blocking voids in the bed.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

Summary of the Invention

According to one aspect of the invention there is provided a wastewater treatment system which comprises, in order downstream, a moving bed biofilm reactor zone, a fixed bed aeration zone, and a settlement zone having a sludge outlet, and which is arranged so that the wastewater flows downwardly in each zone and flows upwardly between at least the moving bed biofilm reactor zone and the fixed bed aeration zone.

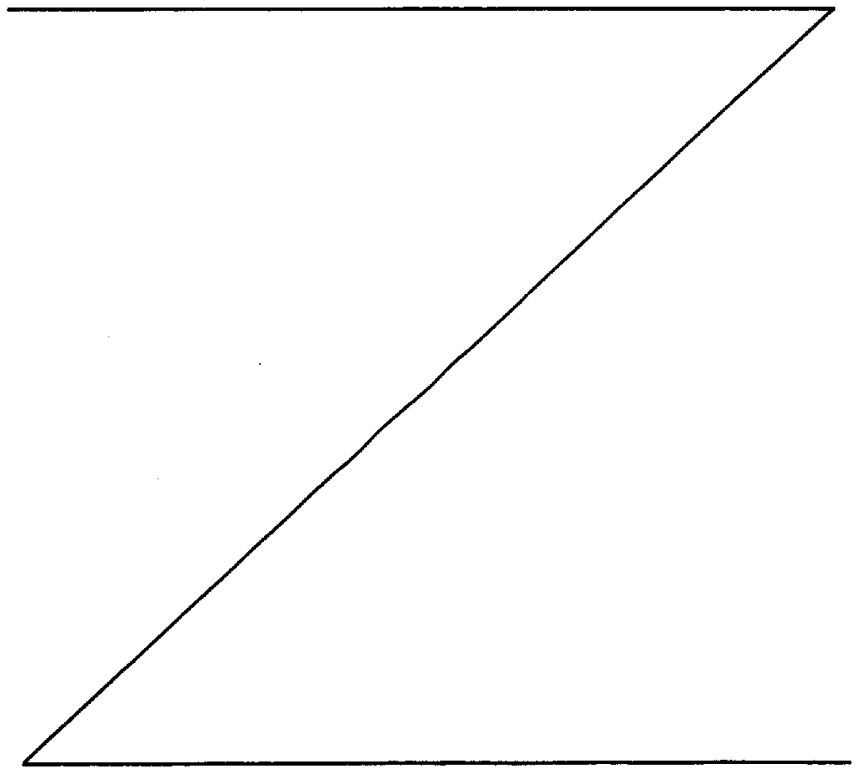
According to a second aspect of the invention there is provided a single unit comprising a system according to the first aspect of the invention, the zones being contiguous.

According to another aspect of the invention there is provided a method for treating wastewater, which comprises passing the wastewater through a system according to the first aspect of the invention, and removing sludge.

The present invention is based on the discovery that the disadvantage of plugging or obstruction in the fixed bed zone, during biological treatment can be reduced by

pre-treatment in a moving bed biofilm reactor (MBBR). In the novel coupling of a MBBR and a fixed bed aeration zone, the MBBR allows a higher flow rate and presents a relatively high surface area, without plugging.

In a preferred embodiment, the invention provides effective, economical wastewater and sewage treatment. It is of potential value in new systems and is adaptable to the retrofitting of existing plants which become overloaded and/or where treatment criteria become more stringent. The invention is of particular value where it is necessary or desirable to provide a compact sewage treatment process, which incorporates the main biological and final settlement processes. The increased surface area means that the essential zones can be put in one housing, i.e. packaged to incorporate the major items of plant. Settled sewage is fed into the front of the treatment unit and gravitates through the biological and settlement zones, to provide a treated effluent. Thus, the respective units' treatments



are essentially unseen, the combination being provided with simple connections at the inlet and the outlet.

Description of the Invention

The apparatus and method of this invention may be essentially conventional, in wastewater treatment, except for the MBBR. The MBBR comprises a tank which, in addition to an inlet and an outlet for the sewage under treatment, comprises an inlet for oxygen, e.g. as air, to be introduced under pressure. Within the reactor, a buoyant medium is present, providing surfaces on which microbial growth can occur, encouraging constant oxygen uptake. The MBBR as the first zone discourages the growth of filamentous bacteria, which improves the settlement characteristics of the waste solids. The medium preferably comprises discrete pieces of, say, plastics material, which preferably include an internal surface, such that solids are not removed by attrition between the pieces. An especially suitable material of this type is known as "Kaldnes" medium, and is described in detail in EP-A-0575314.

In itself, Kaldnes medium provides a surface area of, say, 300 m^2/m^3. By way of example only, a specific area of 500 m^2/m^3 corresponds to 300 m^2/m^3 if the zone is filled to 60% of its volume with Kaldnes medium. This effectively increases the surface area capacity of conventional 3 and 4 cell reactors by as much as 37.5% and 27.27% respectively.

The MBBR zone preferably has a sieve positioned at the outlet to prevent loss of the medium into the next zone. Aeration may be provided by sparging or bubble aerators.

In sequence after the MBBR, there may be one, two or more further aeration zones. These may be of conventional, fixed bed, type. Again, aeration may be provided, by means of sparge pipes. Finally, there may be a conventional settlement zone.

Typically, the MBBR is a completely mixed reactor, while the subsequent fixed bed aeration zones involve plug

flow. These latter zones may comprise, for example, a structured medium such as Munter's medium. Alternatively, they may comprise a random medium, and this may offer some flexibility in the design of the apparatus.

In one embodiment of the invention, apparatus comprises a combination of a MBBR, a fixed film random medium submerged filter and a lamella settler for the biological treatment of crude and settled sewage for populations of up to 2000. Typically, the containment structure for the process is split into two sections. One section has the MBBR which is essentially Kaldnes medium aerated by sparge pipes; this section also contains the lamella settlers. The other section contains fixed film random medium which is also aerated by sparge pipes. In the overall process, sewage is fed to the MBBR which acts as a roughing stage, then into the fixed film random media submerged filter which acts as a nitrifying stage, and finally into the lamella settlers which separate bacterial solids from biological reactors, to allow final discharge.

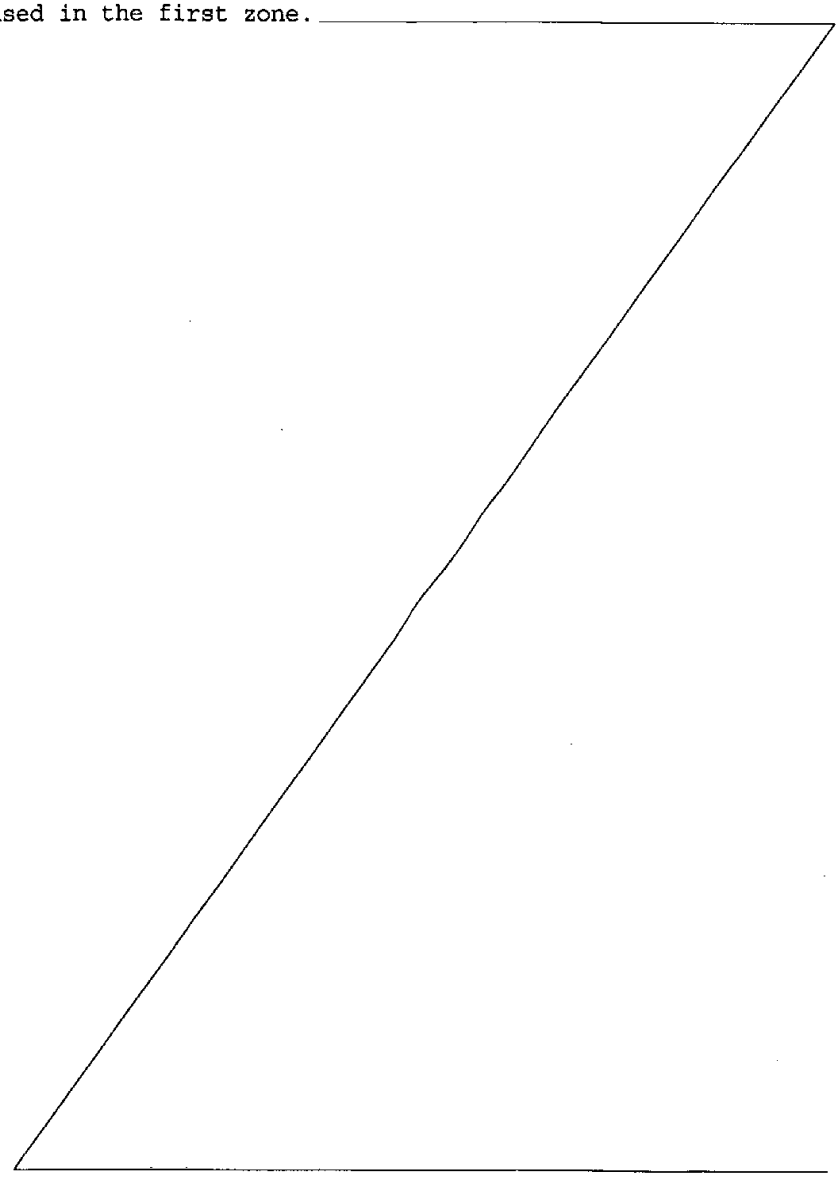
Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

The invention will now be described by way of example only, with reference to the accompanying, schematic drawings. Each drawing shows an embodiment of the invention (not to scale).

Figure 1 shows apparatus comprising four zones, respectively a MBBR 10 containing Kaldnes medium 11 and having a liquid inlet 12 and aerator 13; two fixed bed aeration zones 20 and 30 containing Munter's medium 21, 31 and having air feeds 22 and 32; and a settlement zone 40 including settlement tubes 41, a liquid outlet 42 and a

sludge outlet 43. The water flows downwardly in each aeration zone; conduits 15, 25, 35 are provided for treated water to flow up and into the next zone.

The Kaldnes medium can be loaded up to 10 $kg/m^3/d$, and still provide effective treatment. In normal applications, the first zone will be loaded between 2 and 4 kg $BOD/m^3/d$. Hence, only coarser structured medium (100 m^2/m^3) can be used in the first zone.



The introduction of Kaldnes medium into the first zone in a unit which only comprises fixed structured medium treating 20 kg BOD/d, and maintaining an effluent quality of 30 mg/l SS, 20 mg/l BOD, will allow it to treat 27 kg BOD/d to the same treatment standard. Varying the percentage fill of the first zone allows the same size treatment unit to be used over a wide range of loadings.

Performance trials have been undertaken on comparable units, one with fixed structured medium only and one with Kaldnes medium introduced into the first zone. At identical loadings, there was an improvement in Ammoniacal Nitrogen removal of up to 21%.

Figure 2 is a schematic representation, in plan sectional view, of an alternative embodiment. This utilises a random medium (not shown) in the zones 20 and 30, thereby allowing the illustrated, compact shape.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A wastewater treatment system which comprises, in order downstream, a moving bed biofilm reactor zone, a fixed bed aeration zone, and a settlement zone having a sludge outlet, and which is arranged so that the wastewater flows downwardly in each zone and flows upwardly between at least the moving bed biofilm reactor zone and the fixed bed aeration zone.

2. A system according to claim 1, in which the reactor zone comprises a buoyant medium and a forced oxygen supply.

3. A system according to claim 2, in which the medium comprises discrete pieces of plastics material having an internal surface.

4. A system according to any one of the preceding claims, which comprises two fixed bed aeration zones.

5. A system according to any one of the preceding claims, wherein the fixed bed comprises a structured medium.

6. A system according to any one of claims 1 to 4, wherein the fixed bed comprises a random medium.

7. A single unit comprising a system according to any one of the preceding claims, the zones being contiguous.

8. A method for treating wastewater, which comprises passing the wastewater through a system according to any one of the preceding claims, and removing sludge.

9. A wastewater treatment system substantially as herein described with reference to any one embodiment and its accompanying drawing.

10. A single unit substantially as herein described with reference to any one embodiment and its accompanying drawing.

11. A method for treating wastewater substantially as herein described with reference to any one embodiment and its accompanying drawing.

DATED this 18th Day of May, 2000

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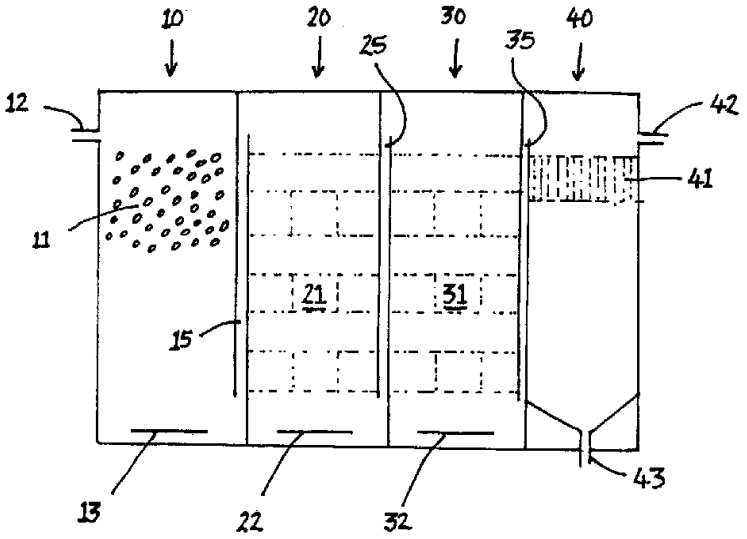
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FIG. 1

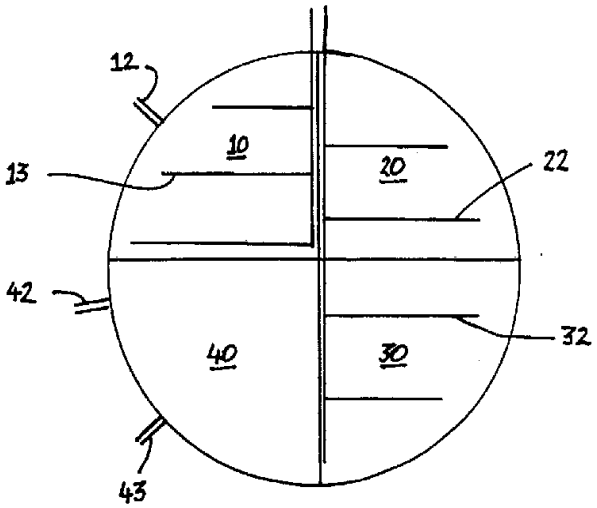
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FIG. 2