METHOD AND SYSTEM FOR TREATING A FLUID FLOW

Abstract: Method for treating a fluid flow, particularly for irrigation in substrate culture, comprising the steps of: -providing a fluid flow; -subsequently carrying the fluid flow through a reactor vessel, wherein oxygen is supplied to the reactor vessel and wherein the reactor vessel comprises micro-organisms on a granular carrier material which decompose organic material in the fluid flow when oxygen is supplied to the reactor vessel; and -discharging from the reactor vessel an oxygen-rich fluid flow comprising micro-organisms from the reactor vessel.
METHOD AND SYSTEM FOR TREATING A FLUID FLOW

The present invention relates to a method and system for treating a fluid flow, particularly for irrigation in substrate culture.

It is particularly in substrate culture, wherein crops are cultivated on substrates of for instance rock wool instead of culture soil, that the loss of crops due to infection with harmful substances such as bacteria and/or viruses is a great problem. The infection of and possible accompanying loss of crops is found to be a greater problem when compared to cultivation in for instance conventional culture soil.

In order to combat this loss it is known to treat the fluid flow used for irrigation in order to remove as many micro-organisms as possible from this fluid flow. This has heretofore not yet had the desired results in respect of reducing loss.

As alternative or additional measure it is known to use chloride to treat the fluid flow. This is however not the desired solution for the horticultural industry since it is in many cases not desirable to apply chemicals, wherein the danger arises of exceeding chloride values, which can have the result that the products may not be sold.

It is therefore an object, in addition to others, of the present invention to provide an efficient and/or effective method for treating a fluid flow.

This object, among others, is achieved with a method according to the appended claim 1. This object, among others, is more particularly achieved with a method for treating a fluid flow, particularly for irrigation in substrate culture, comprising the steps of:

- providing a fluid flow;
- subsequently carrying the fluid flow through a reactor vessel, wherein oxygen is supplied to the reactor vessel and wherein the reactor vessel comprises micro-organisms on a granular carrier material which decompose organic material in the fluid flow when oxygen is supplied to the reactor vessel; and
- discharging from the reactor vessel an oxygen-rich fluid flow comprising micro-organisms from the reactor vessel.

Carrying the fluid flow, in which micro-organisms which decompose organic material are present, through a reactor vessel creates an outgoing fluid flow with low concentrations of these organic nutrients, so that the multiplication of harmful bacteria still possibly present, for instance in this
fluid flow, is limited. In addition to the fact that the micro-organisms present in the reactor vessel need an oxygen-rich environment to function properly, supplying oxygen to the reactor vessel has the additional advantage that the outgoing fluid flow also comprises high concentrations of oxygen and is preferably saturated with oxygen. The multiplication and action of anaerobic bacteria still possibly present in this fluid flow, and for instance further downstream in the conduits and the substrates, is then combatted by these high concentrations of oxygen. Oxygen also ensures a better (root) growth.

Other than according to the prevailing view that the fluid flow, for instance for irrigation, should contain the fewest possible micro-organisms, the outgoing fluid flow according to the invention preferably comprises a substantial concentration of the micro-organisms present in the reactor vessel. Without being limited to this theory it is assumed that, by providing a fluid flow having therein micro-organisms not harmful to cultivation, this fluid flow is less susceptible to infection with potentially harmful bacteria.

The fluid flow coming from the reactor vessel is therefore preferably low in organic material, comprises high concentrations of oxygen and comprises some concentrations of micro-organisms from the reactor vessel.

The reactor vessel is preferably embodied as upright cylinder comprising a quantity of carrier material, for instance in the form of clay granules, which form a favourable habitat for the micro-organisms. The fluid flow to be treated is carried into the reactor vessel so that an aqueous environment is created therein for at least a part of the carrier material, so that the micro-organisms present thereon can decompose the organic material in that fluid flow.

It is advantageous here that carrying the fluid flow through the reactor vessel comprises of spraying the fluid flow onto the granular material from the upper side. The fluid is preferably sprayed over the largest possible, preferably the whole, surface area of the reactor vessel so as to thus make the active surface area as large as possible. The fluid flow to be treated then preferably flows from the top downward into the reactor vessel. The outlet for the fluid flow is preferably located on or close to the underside of the reactor vessel. If the fluid remains for a sufficiently long time in the reactor vessel, substantially all the organic material present is preferably decomposed therein.

According to a preferred embodiment, the method also comprises of controlling the supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined
fluid level in the reactor vessel, wherein the predetermined fluid level is lower than the filling height of the granular carrier material in the reactor vessel. It is advantageous here that not all the granular carrier material lies below the fluid level in the reactor vessel, so that an environment is created above this fluid level which, although wet, is very oxygen-rich. This combination of environments produces an improved operation of the reactor vessel. The supply and discharge of the fluid to and from the reactor vessel is then controlled such that the fluid level in the reactor vessel is adjusted to a predetermined fluid level, or preferably falls within a predetermined range of the fluid level.

In order to prevent the biological activity in the reactor vessel decreasing too much, for instance due to excessive discharge of micro-organisms from this reactor vessel, it is advantageous for the method to also comprise the step of controlling the supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined minimal biological activity in the reactor vessel. This ensures a minimal quantity of micro-organisms present in the reactor vessel which can serve to maintain a resistant population. Measurement of the biological activity can for instance take place by measuring the organic material still present in the outlet, which is then indicative of the effectiveness and thereby the biological activity in the reactor vessel.

According to a further preferred embodiment, the method also comprises of measuring a pressure difference, in particular changes thereof, over a filter located downstream of the outlet. When a measured pressure difference over this filter increases rapidly, this is an indication that the filter is becoming clogged more quickly due to an excessive quantity of micro-organisms detaching from the carrier material. The supply and/or discharge of fluid into or out of the reactor vessel can be modified in order to combat the rapid decrease in biological activity.

Measurement of the biological activity can however also take place by measuring the oxygen concentration in the reactor vessel, preferably close to the upper side thereof. Now that the oxygen is preferably supplied close to the underside of the reactor vessel, the decrease in the oxygen concentration relative to a predetermined level on the upper side is an indication of the biological activity of the micro-organisms. The predetermined level can be determined on the basis of the quantity of oxygen added. If the measured oxygen concentration falls below a predetermined level, the supply and/or discharge of the fluid flow can then be modified such that the fluid with micro-organisms for instance remains present for longer in the reactor vessel for the purpose of further multiplication. It is also possible for the quantity of oxygen in ingoing and outgoing flows to be measured in order to determine an indication of the biological activity.
Although control of the supply and/or discharge can take place by controlling the flow rates of the supply and/or discharge by means of suitable valves, it is advantageous for the control to comprise of feeding a quantity of fluid from the outlet back to the inlet. With such a feedback the fluid level in the reactor vessel and/or the biological activity in the reactor vessel can for instance be maintained as desired. The feedback conduit is situated here between the outlet of the reactor vessel and an outfeed for outfeed of the treated water, for instance to the irrigation system. The quantity of fluid which is fed back via the feedback conduit can for instance be controlled using a valve to this outfeed. It is advantageous here that the filter with pressure difference measurement as described above is incorporated into the feedback conduit.

Particularly when a part of the granular carrier material lies above the fluid level in the reactor vessel, it is important that this material in particular is kept sufficiently wet so as to sustain the micro-organisms present thereon. For this purpose the supply of fluid into the reactor vessel is preferably maintained at a minimal flow rate, and the supply is more preferably maintained at a predetermined flow rate. When the availability of the fluid flow to be treated is not sufficient to reach this predetermined flow rate, it is advantageous that the method also comprises the step of feeding a quantity of fluid from the outlet back to the inlet of the reactor vessel such that the supply of fluid reaches that predetermined flow rate. If the fluid flow provided is not sufficient to reach this flow rate, this fluid flow is supplemented with the fluid flow coming from the reactor vessel. It is for instance possible for this purpose to control the valve to the outfeed as described above such that the flow rate of the supply remains substantially constant.

According to a further preferred embodiment, the micro-organisms comprise nitrifying soil bacteria.

According to a further preferred embodiment, the granular carrier material comprises clay granules. Such material forms a good substrate for the micro-organisms. Geo-hydro granules 8-16, particularly with a weight of about 350 kg/m², are for instance suitable. The carrier material, preferably in the form of clay granules, preferably has a large specific surface area so that the contact area with the fluid to be treated is large. The carrier material more preferably has a specific surface area greater than 600 m²/m³.

The invention also relates to a method for irrigating at least one substrate in the substrate culture, comprising the steps of treating a fluid flow according to the invention and irrigating the substrate with the treated fluid flow. The loss of crops during cultivation is thus combatted. It should be noted here that it is not strictly necessary to supply the fluid flow coming from the reactor vessel
directly to the substrate for irrigation thereof. It is for instance possible to first store the treated
water in a suitable reservoir and then supply it, when necessary, to the substrate via per se known
irrigation systems.

The invention also relates to a system for treating a fluid flow according to the invention,
particularly for irrigation in substrate culture, comprising:
- an infeed for receiving the fluid flow to be treated;
- an outfeed for outfeed of the treated fluid flow;
- a reactor vessel between the infeed and outfeed, wherein the reactor vessel
  comprises an inlet coupled to the infeed, an outlet coupled to the outfeed, a feed for
  oxygen which is configured to supply oxygen to the reactor vessel; and
- a pump and control system for carrying and controlling the fluid flow between the infeed
  and the outfeed.

An incoming fluid flow can be treated efficiently with such a system for the purpose of obtaining a
fluid flow which is preferably rich in oxygen, low in organic material and which comprises micro-
organisms from the reactor vessel. The pump and/or the control system are configured here to
modify the flows in the system such that sufficient decomposition of organic material is achieved
and the oxygen concentration in the water is sufficiently high. In order to create the division of a
drier and a submerged environment for the carrier material in the reactor vessel as described above
it is advantageous that the reactor vessel comprises at least one sensor for measuring the fluid level
in the reactor vessel. The control system can then be adjusted on the basis of the measurements
from this sensor for the purpose of maintaining the fluid level in the reactor vessel. Although it is
possible for the fluid level to be measured with a single sensor, the reactor vessel preferably
comprises a plurality of sensors, which can for instance detect an upper and a lower limit of the
water level, subject to which the control system and/or the pump can adjust the water level in the
reactor vessel. The sensors can for instance comprise floats.

For efficient control of for instance the fluid level in the reactor vessel the system preferably also
comprises a feedback conduit between the outlet of the reactor vessel and the inlet of the reactor
vessel. The control system is preferably configured here to control the fluid flow through the
feedback conduit, for instance by adjusting the flow rate with a suitable valve and/or adjusting the
power and/or frequency of the pump.
According to a further preferred embodiment, the system comprises a flow rate sensor for measuring the flow rate of the supply of fluid into the reactor vessel, wherein the control system is configured to feed a large quantity of fluid from the outlet back to the inlet such that the supply of fluid reaches a predetermined flow rate. This ensures sufficient supply of fluid into the reactor vessel to sustain the wet environment above the fluid level in the reactor vessel.

According to a further preferred embodiment, the feed of oxygen is located close to the underside of the reactor vessel and wherein the reactor vessel comprises close to the upper side an oxygen sensor which is configured to measure the oxygen concentration, and wherein the control system is configured to control supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined minimal biological activity in the reactor vessel. This makes it possible to adjust the biological activity in the reactor vessel and provide for a healthy population of micro-organisms in the reactor vessel, as already described in greater detail above.

As alternative or as addition to measuring the biological activity, a filter is preferably provided downstream of the outlet, wherein pressure sensors are provided for measuring a pressure difference, particularly changes thereof, over this filter. The control system can be provided for this purpose with suitable processing means. When, as already discussed, a measured pressure difference over this filter increases rapidly, this is an indication that the filter is becoming clogged more quickly due to an excessive quantity of micro-organisms detaching from the carrier material. The supply and/or discharge of fluid into or out of the reactor vessel can be modified to combat the rapid decrease in biological activity. The filter is preferably placed in the feedback conduit.

The present invention is further illustrated on the basis of the following figures which show a preferred embodiment of the system according to the invention and are not intended to limit the scope of the invention in any way, wherein:

- Figure 1 shows a flow diagram of the system; and
- Figure 2 shows the system schematically in perspective.

Figures 1 and 2 show a treatment system 100 for treating a water flow coming from a conduit 7. In this embodiment this conduit is coupled to the outlet for discharging water from growth substrates. The treated water is discharged to an outfeed 9 for further storage in silo 9a, after which it can be used to irrigate substrates in substrate culture with a per se known irrigation system 10.
Referring to figure 2, the system comprises an upright cylindrical reactor vessel 1 which in this embodiment has a diameter of 120 cm and a height of 300 cm. Received in the reactor vessel are granules D, only the upper edge of which is shown schematically. The granules are geo-hydro granules 8-16 with a weight of 350 kg per m². Via infeed 7 the water is distributed over the granules D by pump U via a conduit 2 from the upper side of reactor vessel 2 by means of a sprayer 21, optionally after a UV treatment. In this embodiment the sprayer has a flow rate of 16 m³ per hour. Provided on the underside of reactor vessel 1 is an outlet 3 which via a system pump 4 and valve 5 can discharge the treated water via outfeed 9.

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The flow rate of sprayer 21 is determined using pressure gauge P2. In order to ensure that the granular material D, particularly in the upper side of reactor vessel 1, stays sufficiently wet it is important that the flow rate of sprayer 21 is kept as constant as possible, or at least does not drop below a predetermined limit value, in this embodiment 16 m³ per hour. In order to ensure that this flow rate can also be reached when the supply from infeed 7 is too low, a feedback conduit 6 is provided which runs between outlet 3, downstream of pump 4, and inlet conduit 2. The flow rate through feedback conduit 6 can be determined by adjusting, by means of opening and/or closing, of valve 5 arranged between discharge conduit 3 and outfeed 9. When pressure sensor P2 measures an increased pressure, which is indicative of an increased flow rate of sprayer 21, valve 5 can be opened further so that more treated water can be pumped to outfeed 9 and the supply from conduit 6 decreases. The production of system 100 is then optimal.

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It is even possible here for system 100 to operate without any discharge of water in the system, wherein the water is circulated constantly via inlet 2, outlet 3 via pump 4 and feedback conduit 6. In order to prevent too low a water level as a result of evaporation, suppletion of water also takes place during this recirculation. Such a recirculation can be particularly important when starting up the system, as will be discussed in more detail below.

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In addition to the constant flow rate of sprayer 21 it is important that the water level, designated with the letter W and only the water surface of which is shown in the figure, remains within a predetermined range. In this embodiment two floats NO are arranged at heights of respectively 80 cm and 120 cm above the underside of reactor vessel 1. These floats act as sensors for determining the water level in reactor vessel 1, wherein the water level has to remain between these two sensors. The water level in reactor vessel 1 can be adjusted within this desired range by modifying the frequency of system pump 4. When the water level is too high, wherein upper sensor NO measures water, the frequency of the system pump can for instance be increased, while in the case
of a measurement by the lower sensor NO the frequency of system pump 4 can be reduced, whereby the water level will rise again.

Incorporated into reactor vessel 1 on the upper side for safety purposes is a sensor LHH which determines the maximum water level in the reactor vessel. In the case of a signal from this sensor the system will be switched off. Also incorporated into discharge conduit 3 is a sensor LLL, which detects whether water is flowing through this conduit. If no water is detected, the system will once again switch off automatically.

Present in the reactor vessel is a broad population of (nitrifying soil) bacteria, which decompose organic material when oxygen is supplied. The clay granules serve here as carrier material for these bacteria and provide a very large active surface area for these bacteria. Organic substances present in the fluid flow are decomposed through the agency of these bacteria. In order to ensure that the operational climate is optimal for the bacteria, an oxygen feed 11, which supplies a flow of oxygen to the reactor vessel using a pump, is provided on the underside of reactor vessel 1. In this embodiment 30 m³ is supplied to reactor vessel 1 per hour at 0.2 bar.

When starting up the system, i.e. upon first use, it is important that the population of bacteria in the reactor vessel is sufficiently large and develops into a sufficiently large population for effective functioning of the system. The system can for this purpose be set to the recirculation position, which means that the system circulates the water via feedback conduit 6 in order to ensure that no bacteria are discharged via outfeed 9.

A filter 13 with pressure sensors 14 on either side thereof is moreover arranged in feedback conduit 6. These pressure sensors 14 measure the pressure difference over filter 13 and, if a rapid decrease in the pressure difference over filter 13 is detected, this is an indication that a large quantity of micro-organisms are being released from the reactor vessel. In order to maintain the population in the reactor vessel the discharge from the vessel can limited so that the population can recover by way of multiplication.

During use the outflow from outfeed 9 is determined by the position of valve 5, which is determined subject to the pressure measurement by sensor P2. Organic material is substantially wholly removed from the fluid flow at outfeed 9 by the filtering action of the reactor vessel since this material has been decomposed by the bacteria on carrier material B. The supply of oxygen for the oxygen supply system 11 is moreover so great that the water from outfeed 9 is substantially wholly saturated with oxygen. An additional advantage is that bacteria will also be flushed out of
reactor vessel 1 so that the water in outfeed 9 also comprises a certain concentration of bacteria. This combination of factors produces a fluid flow which is highly suitable for irrigating substrates in substrate culture, wherein infection by harmful bacteria is precluded as far as possible. On the one hand due to the high concentration of oxygen, so that anaerobic bacteria are afforded less opportunity to develop, and on the other due to the absence of nutrients for these bacteria. The build-up of a population of the beneficial soil bacteria in the substrates also contributes toward reduction in losses.

The present invention is not limited to the shown embodiments but also extends to other embodiments falling within the scope of the appended claims.
CLAIMS

1. Method for treating a fluid flow, particularly for irrigation in substrate culture, comprising the steps of:
   - providing a fluid flow;
   - subsequently carrying the fluid flow through a reactor vessel, wherein oxygen is supplied to the reactor vessel and wherein the reactor vessel comprises micro-organisms on a granular carrier material which decompose organic material in the fluid flow when oxygen is supplied to the reactor vessel; and
   - discharging from the reactor vessel an oxygen-rich fluid flow comprising micro-organisms from the reactor vessel.

2. Method as claimed in claim 1, wherein carrying the fluid flow through the reactor vessel comprises of spraying the fluid flow onto the granular material from the upper side.

3. Method as claimed in claim 1 or 2, comprising of controlling the supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined fluid level in the reactor vessel, wherein the predetermined fluid level is lower than the filling height of the granular carrier material in the reactor vessel.

4. Method as claimed in at least one of the foregoing claims, also comprising of controlling the supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined minimal biological activity in the reactor vessel.

5. Method as claimed in claim 4, also comprising the step of measuring a pressure difference, in particular changes thereof, over a filter located downstream of the outlet as indication of the biological activity.

6. Method as claimed in claim 4 or 5, also comprising of supplying oxygen from the underside of the reactor vessel and measuring an oxygen concentration as indication of the biological activity.

7. Method as claimed in claim 4, 5 or 6, also comprising of measuring the quantity of oxygen in ingoing and outgoing flows as indication of the biological activity.
8. Method as claimed in at least one of the claims 3 or 4, wherein the control comprises of feeding a quantity of fluid from the outlet back to the inlet.

9. Method as claimed in at least one of the foregoing claims, also comprising of feeding a large quantity of fluid from the outlet back to the inlet of the reactor vessel such that the supply of fluid reaches a predetermined flow rate.

10. Method as claimed in at least one of the foregoing claims, wherein the micro-organisms comprise nitrifying soil bacteria.

11. Method as claimed in at least one of the foregoing claims, wherein the granular carrier material comprises clay granules with a specific surface area of more than 600 m²/m³.

12. Method for irrigating at least one substrate in the substrate culture, comprising the steps of treating a fluid flow as claimed in at least one of the foregoing claims and irrigating the substrate with the treated fluid flow.

13. System for treating a fluid flow, particularly for irrigation in substrate culture, comprising:
- an infeed for receiving the fluid flow to be treated;
- an outfeed for outfeed of the treated fluid flow;
- a reactor vessel between the infeed and outfeed, wherein the reactor vessel is configured to hold granular carrier material for micro-organisms and wherein the reactor vessel comprises an inlet coupled to the infeed, an outlet coupled to the outfeed, a feed for oxygen which is configured to supply oxygen to the reactor vessel; and
- a pump and control system for carrying and controlling the fluid flow between the infeed and the outfeed.

14. System as claimed in claim 13, wherein the reactor vessel comprises at least one sensor for measuring the fluid level in the reactor vessel and wherein the control system is configured to control the supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined fluid level in the reactor vessel.

15. System as claimed in claim 13 or 14, also comprising a feedback conduit between the outlet of the reactor vessel and the inlet of the reactor vessel, wherein the control system is configured to control the fluid flow through the feedback conduit.
16. System as claimed in claim 15, wherein the inlet comprises a flow meter for measuring the flow rate of the supply of fluid into the reactor vessel, wherein the control system is configured to feed a large quantity of fluid from the outlet back to the inlet such that the supply of fluid reaches a predetermined flow rate.

17. System as claimed in at least one of the foregoing claims, wherein the system also comprises at least one sensor for determining an indication of the biological activity in the reactor vessel, wherein the control system is configured to control supply and/or discharge of fluid into or out of the reactor vessel for the purpose of maintaining a predetermined minimal biological activity in the reactor vessel.

18. System as claimed in claim 17, also comprising a filter downstream of the outlet, wherein pressure sensors are provided for measuring a pressure difference, particularly changes thereof, over this filter, wherein the control system is configured to determine the indication of the biological activity in the reactor vessel on the basis of the pressure difference.

19. System as claimed in at least claims 15 and 18, wherein the filter is arranged in the feedback conduit.
## A. CLASSIFICATION OF SUBJECT MATTER

INV. C92F3/04 C02F3/10 CQ2F3/26

ADD.

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)

C02F A01G

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

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

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search

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