



(10) International Publication Number
WO 2009/129963 A2

(43) International Publication Date
29 October 2009 (29.10.2009)

PCT

- (51) **International Patent Classification:**
C02F 3/12 (2006.01) **C02F 3/30** (2006.01)
C02F 3/20 (2006.01)
- (21) **International Application Number:**
PCT/EP2009/002814
- (22) **International Filing Date:**
17 April 2009 (17.04.2009)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
MI2008A742 23 April 2008 (23.04.2008) IT
- (71) **Applicant** (*for all designated States except US*): **CIEM
IMPIANTI S.R.L.** [IT/IT]; 39, Via T. Tasso, 1 -21100
Varese (IT).
- (72) **Inventors; and**
- (75) **Inventors/Applicants** (*for US only*): **BAIO, Emanuele**
[IT/IT]; 6, Via Pietro Nenni, I -21046 Malnate (IT). **PA-
GANI, Dario** [IT/IT]; 18, Via della Fomace, 1 -21100
Varese (IT).
- (74) **Agent:** **FERRAILOLO, Ruggero**; FERRAILOLO S.R.L.,
Via Napo Torriani, 10, 20124 Milano (IT).
- (81) **Designated States** (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ,
EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO,
NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG,
SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA,
UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

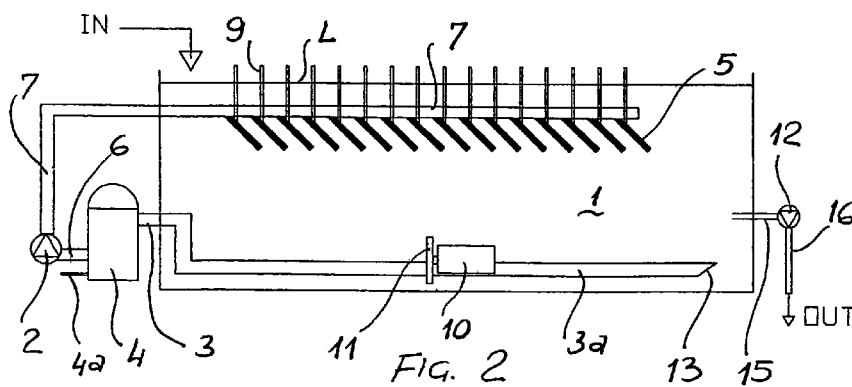
Declarations under Rule 4.17:

- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

- (54) Title:** PROCESS AND PLANT TO PURIFY POLLUTED WATERS



- (S7) Abstract:** In the first step of the process and with the plant implementing it, the effluent mixed with air is blown at a pressure in the pipe network of at least 2 bars, and the stream of the effluent-air mixture is supplied at a distance from the bottom of the tank varying from about half the effective height of the tank to about the surface of the liquid in the tank, whereas in the second step of the process the effluent treated in the first step is stirred in the tank without blowing air by means of a stirrer that is able to break the biological foam previously formed.

Title: Process and plant to purify polluted waters

Description

The present invention relates to a process and a plant for purifying polluted waters, in particular for carrying out a biological purification for reducing the nitrogen content and the bad smell in highly polluted waters, more specifically of live-
5 stock sewage, digestates from biogas and highly polluted effluents refractory to biological purification and designed for agronomic spreading or to achieve a complete purification of said sewages or effluents.

In the whole of the following text, "sewage" means all polluted waters of
10 zootechnical origin, among which for instance: sewage, poultry manure, digestates from biogas, etc.; "effluents" means all polluted waters that are not of zootechnical origin and contain a high or very high load of nitrogen and pollutants also very refractory to purification.

State of the art

15 The state of the art includes processes and plants of various types, as summarized below.

a. Anaerobic treatments, in which the sewage is treated in one-stage or multi-stage digesters in which the organic substance is turned into biogas by means of biological methods. The whole of organic nitrogen is turned into ammonia nitrogen.

20 b. Concentration by filtration, in which the soluble fraction of the sewage or effluent is completely separated from the solid, suspended colloidal fraction using membrane-type forced filtration systems. The output of the plant is a fraction of sewage or effluent (about 80-90% by volume) separated from its polluting charge.

c. Concentration by evaporation, in which the sewage or effluent is heated
25 up to water evaporation. Thus the polluting charge is concentrated in a lower volume.

d. Stripping, in which the sewage or effluent is heated to about 40-50°C and pH is raised to > 9 with sodium carbonate or another base. In a hermetically sealed container air is bubbled from the bottom, which air extracts by stripping formed NH₃ at predefined temperature and acidity conditions. The extracted gas is neutralized with acids, thus obtaining ammonium salts. After the treatment, the sewage or effluent is cooled and neutralized with acid. Remaining air must be treated before being sent into the atmosphere.

e. Traditional biological purification, in which the sewage or effluent is treated by activating a bacterial biomass by a series of anaerobic (in some cases), aerobic (nitro) and anoxic (de-nitro) processes. The biomass thus activated oxidizes in the aerobic step the organic substance and ammonia nitrogen present in the sewage or effluent and turns them into CO₂, NO₃ and new organic substance. In the following anoxic step, NO₃ is reduced to N₂, which is sent into the atmosphere, consuming new organic substance. The sewage or effluent is oxygenated by systems using membranes, flow-jet, surface turbines sending the sewage or effluent into the air and oxygenating it.

f. European Patent No. 0 907 615 to Odobez discloses a container in which the sewage or effluent is reduced by biological processes in one SBR tank (Sequency Batch Reactor) with the alternation of nitrification (nitro) steps in which the sewage or effluent is oxygenated at high pressure with suitable oxygenizers whose means causing a so-called "Venturi effect" recall atmospheric air, and de-nitrification (de-nitro) steps in which the sewage or effluent is stirred from the system itself at low pressure, the oxygenizers being installed near the bottom of the tank. Eventually, the sewage or effluent is discharged in a batch mode.

g. The Applicant and other institutions working in the present technical

field are performing researches and tests for implementing microbiological processes and plants in which energy consumptions are reduced with respect to the state of the art.

Drawbacks of the prior art

5 The solutions listed above (except for “e-f”) do not effectively reduce nitrogen, but only move or transform it.

 Anaerobic digestion plants produce biogas by decomposing the organic fraction only, but without removing the nutrients (N and P). Nitrogen is almost completely turned into ammonia nitrogen, with higher risks of NH_3 emissions into the atmosphere.
10

 Filtration systems, more or less selective or forced, achieve a simple separation of organic substance and nutrients.

 Evaporation systems basically reduce only the volume of polluted sewage with a high energy consumption.

15 Stripping requires the use of dangerous chemicals, also with a high energy consumption for heating the sewage or effluent.

 Biological purification plants are very sensitive to the variation of toxic substances, among which NH_3 . This type of plants, therefore, must be equipped with a suitable oxygenation system for supporting the biological process to reduce the input of high polluting loads.
20

 “Odobez technology”, though having high reduction rates, leads to high energy consumptions since it is an industrial technology for the zootechnical field. SBR sequence is not optimal since discontinuous feed and discharge cause even strong variations of the chemical-physical-biological status of the process inside the processing tank and threaten the effectiveness thereof. Moreover, since in the anoxic
25

step the container works at low pressure, the mixing of sewage or effluent in the tank is limited during this step. The control of the bacterial biomass is achieved only by the flotation due to bottom oxygenation, so that it is not possible to manage with accuracy biomass concentration in the tank and therefore fully manage the treatment and the hydraulic retention time (HRT). More to the point, it is difficult to control the biological foams building up due to the strong aeration during the high pressure step.

Disclosure of the invention

It should be pointed out that in the present description and in the claims, “high pressure” as referred to air mixed with sewage or effluent being blown during the first process step means an optimal working pressure above 2 bars and in particular of about 4 bars in processes treating sewage of zootechnical origin, and pressures of at least 7 bars in processes treating effluents with a high load of substances refractory to biological purification.

It should also be pointed out that in the present description and in the claims, “conventional oxygenizers” or simply “oxygenizers” means oxygenizers according to Italian Patent No. 1 147 264, or known equivalent oxygenizers, i.e. oxygenizers equipped with means for sucking up atmospheric air which mixes with the fluid injected upstream due to the here conventionally so-called “Venturi effect” and for blowing such air together with the sewage or effluent under pressure supplied by a pump.

The process can take place in one processing tank with continuous feed and discharge, in which two steps alternate, a first nitrification step and a second denitrification step. Being a continuous process, the sewage or effluent present in the processing tank must have already been treated and be ready for being discharged; sewage or effluent supplied from outside is the component required for bacterial me-

tabolism and is therefore immediately consumed. In the first nitrification step, in which the pressure in an upper pipe network, also referred to as oxygenation network, is kept above 2 bars, a mixture of air and sewage or effluent is blown into the tank by means of conventional oxygenizers which, as is known, are provided with means sucking up air by "Venturi effect", the bacterial biomass present oxidizes the organic substance and ammonia nitrogen; the first one is turned into carbon dioxide and the second one into nitric and nitrous nitrogen, whereas a portion both of organic substance and of nitrogen is used for forming new bacterial biomass. Alternating times and step duration are selected depending on the nitrogen load being input. As a new feature, in the first step of the process sewage or effluent mixed with air is blown at a pressure of at least 2 bars in the upper pipe network and at a distance D from the bottom of the tank varying from about half the tank height to about the liquid surface in the tank, and in the second step of the process sewage or effluent treated in the first step are stirred with a stirrer without blowing air and keep the biomass suspended and break the foams that might have been formed in the first step.

In particular, the aforesaid distance D from the bottom of the tank is defined by the following function:

$$D = \log_a x$$

wherein

$$a = \frac{(x^4 + x^3)}{k}$$

wherein x is the effective height of the tank, i.e. the maximum height of the liquid in the tank, k is an empirical constant depending on the type of sewage or effluent and on the type of treatment or purification used.

Since in the plant according to the invention and in the first high pressure

step the concentration of dissolved oxygen (DO) within the oxygenizers is high so as to create a positive redox potential (RedOX) condition, when the process treats sewage it is possible to keep in the volume of liquid in the tank conditions of dissolved oxygen (DO) and redox potential (RedOX) in which $DO < 0.1 \text{ mg/l}$ and $RedOX =$
5 $= -200 \text{ mV}$, whereas $DO = 0 \text{ mg/l}$ and $RedOX = -400 \div 300 \text{ mV}$ in the second step, which causes a reduction of about 85% of nitrogen and of about 80% of organic substance. Sewage getting out of this process can undergo further treatments up to complete purification or can be sent directly to spreading or ferti-irrigation on fields.

In all other cases of treatment or complete purification of highly polluted
10 effluents, OD, RedOX and biomass control conditions vary from application to application.

In all cases of treatment or purification of sewage or effluents the process develops high temperatures above 25°C , both in summer and in winter, which are kept thanks to the oxidative force and to process effectiveness.

15 The plant in which the process is implemented comprises the processing tank receiving from outside the polluted effluent or sewage, at least one pump sucking up effluent or sewage from the bottom of the tank and sending it to a pipe network up to a plurality of oxygenizers supplied by the filtered effluent or sewage and by atmospheric air, a filter being placed between the pump and a pipe sucking up the effluent
20 or sewage from the bottom of the tank, and is characterized in that the pump produces in the pipe network a pressure of at least 2 bars and the discharge openings of the oxygenizers are placed at a distance D from the bottom of the tank varying from about half the effective height of the tank to the surface of the sewage in the tank.

Also referring to the plant, it should be pointed out that the aforesaid distance D is defined by $D = \log_a x$, as explained for the process.
25

Preferably, the oxygenizers are installed in the processing tank with the discharge axis in a position of 8° to 90° with respect to the horizontal, which increases with the depth of the tank.

As an alternative, the processing tank is associated to a closed aeration container in which the sewage or effluent is aerated in the first process step. This alternative is characterized in that the nitro/de-nitro process always takes place in the same processing tank, and in that in the first nitrification step the closed aeration container operates by recirculating and aerating sewage or effluent from the processing tank and in the de-nitrification step said container stops its operation. The supply of polluted water to be treated and the discharge of treated water always occur from the processing tank.

In this alternative, the tank has a small size calculated as a function of process requirements and the closed aeration container is sized so as to grant a sufficient contact time between air and sewage or effluent. A continuous recirculation of sewage or effluent from the bottom of the processing tank takes place between the tank itself and the container. The recirculation can be carried out by the previously mentioned pump or by a dedicated pump. The flow of aerated sewage or effluent is then distributed by means of a generally mechanical stirrer to the whole volume of the processing tank. The plurality of oxygenizers is located in the closed aeration container, which can be placed inside or outside the processing tank. The oxygenizers are installed in the closed aeration container, uniformly distributed on opposite vertical walls thereof.

The closed aeration container is made according to two possible solutions.

In a first solution, the oxygenation pump takes the sewage or effluent from the processing tank through a mechanical filter, and supplies it under high pressure

into the oxygenation network and from the latter into the aeration container by means of a suitable number of oxygenizers. The sewage or effluent thus aerated is supplied back into the bottom of the processing tank, either by gravity or with a pump, in which tank stirring occurs by means of a mechanical stirrer.

5 In a second solution, the oxygenation pump takes the sewage or effluent from the aeration container through a mechanical filter, and supplies it under high pressure back into the oxygenation network in the same oxygenation container by means of a suitable number of oxygenizers. Another pump supplies continuously the aeration container with new sewage or effluent to be aerated from the processing tank.
10 The effluent thus aerated is supplied back into the bottom of the processing tank, either by gravity or with a pump, in which tank stirring occurs by means of a generally mechanical stirrer.

 Moreover, in all the solutions above described and according to processing requirements, the "Venturi effect" in oxygenizers can be increased thanks to a forced
15 aeration system which pressurizes the air intake pipes in oxygenizers increasing the flow rate of air sucked up by "Venturi effect".

 As a new feature, thanks to the plant associated with the forced aeration system the high pressure in the pipe network (> 2 bars) creates within each oxygenizer such a high specific air-liquid exchange surface to enable the transfer into the liquid of
20 the greater air flow rate supplied by the forced aeration system.

 It can thus be inferred that the process can occur in one completely stirred tank CSTR (Completely Stirred Tank Reactors) with continuous supply and discharge from the tank, or in a tank and in a closed aeration container associated to said tank.

 The plant with one processing tank or the one with processing tank associated to
25 the closed aeration container are sized so as to treat the amount of sewage or effluent

that is daily supplied; in other words, the bacterial biomass present in the tank consumes the whole polluting charge.

The plant with only one processing tank contains sewage or effluent that has already been treated as well as the bacterial biomass required for metabolic decomposition. The aforesaid bacterial biomass develops thanks to the alternation of high pressure and absence of pressure and may if necessary be discharged directly together with the treated effluent (plant without control of biomass amount) or kept in the processing tank with sedimentation or filtration systems (plant with control of biomass amount). In the latter case, the fraction of biomass accumulating in excess should be extracted from time to time (i.e. that part of the biomass exceeding the pre-defined value for metabolic decomposition of the daily load of a specific plant).

Moreover, the plant can include means for controlling the biomass amount by means of an inner clarifier or filtration membranes.

The upper pipe network along which the oxygenizers are connected is preferably located in the upper region of the tank so as to optimize the effectiveness of "Venturi effect", whereas a lower pipe network placed on the bottom of the tank sucks up in various points the sewage or effluent by means of the pump to which the upper network is connected, so as to promote the downward flow of sewage or effluent mixed with air.

As an alternative, sewage or effluent is taken from the bottom of the tank by means of one or more independent ducts whose intake openings reach various points near the bottom of the tank.

The size of the upper pipe network, or oxygenation network, and the number of oxygenizers installed along said network in the tank only or in the aeration container depend on the volume and on the chemical-physical characteristics of the efflu-

ent to be treated daily.

Advantages of the invention

The main advantages of the invention are listed below.

5 - There is a lower energy consumption thanks to the lower water head with respect to a plant using "Odobez" technology, the amount of air supplied to water being the same.

10 - Thanks to the plant associated to the forced aeration system, the high pressure in the upper pipe network (> 2 bars) creates inside the oxygenizer such a high specific air-water exchange surface as to enable the transfer into water of the higher flow rate of air supplied by the forced aeration system.

 - The high pressure in the upper pipe network causes in the oxygenizers the effluent or sewage to be pulverized and mixed with air, so as to support a highly effective and easily managed biological process.

15 - The level at which the exit orifices of the oxygenizers lie, which level is always high with respect to the height of the tank and optionally near the surface of the liquid in the tank, as well as the high pressure in the upper network ensure an extremely high effectiveness of the nitrification step.

 - The invention allows to implement more than one type of treatment of polluted effluents.

20 - Treatment of sewage for spreading (or pre-treatment in the case of effluents): the sewage is treated until reaching a reduction of nitrogen of 75-80% so as to be spread onto agricultural soils in compliance with regulations (Directive 91/676/ECC - Nitrate Directive). Oxygen supplied to these plants is exactly the same amount consumed for reducing nitrogen and a part of organic substance. Thus the
25 whole organic charge is not consumed and the discharge obtained from the plant still

has a certain fertilizing power.

- The plant is highly flexible and the process is very stable and effective, thus it is suitable for a large number of highly polluting effluents/sewages.

- The process is always self-adjusting at a temperature of 30-38°C and pH of 7-7.8 thanks to the oxygenation system. Processing values indicated above are optimal for biological purification systems in mesophily.

- Redox potential and oxygen concentration depend on the type of treatment, more or less forced, which is to be carried out, according to users' requirements.

- Eventually, the forced aeration means associated to the plant enable a reduction of processing costs in all types of plants and treatments, with the same sewage or effluent to be treated. As a matter of fact, with the same number of oxygenizers as other plants, the amount of air that can be blown can sometimes be twice as much the one supplied by conventional oxygenizers.

There are three main advantages resulting from the use of a closed aeration container separated from the tank volume:

- Long stainless steel pipe networks are not necessary inside the processing tank, which means lower costs for the plant.

- Since said container is separated from the processing tank, all maintenance operations are much simpler and faster. Moreover, it is no longer necessary to empty the processing tank for maintenance in the upper network and in the oxygenizers immersed in the tank.

- The system is much more flexible for oxygenation management, since there is no longer a strict connection between oxygenation effectiveness (which depends on the level of liquid above the oxygenation network) and retention time (which depends on the volume, and thus on the level, of liquid contained in the tank). In other

words, in order to keep the level in the tank low (and thus a good Venturi effect) it is necessary with the same HRT to build tanks with very large surfaces. Conversely, if an outer aeration container is used, the effectiveness of "Venturi effect" will depend on the pressure set inside the container. It is thus possible to build tanks with r surfaces smaller than the conventional ones.

Description of preferred embodiments

The invention will now be explained in further detail by means of examples of embodiment thanks to diagrams and schematic drawings, in which

- Fig. 1a is a diagram showing the steps and parts of a purification plant that can be regarded as prior art with respect to the one disclosed in European Patent 0 907 615 to "Odobez",

- Fig. 1b is a diagram showing the steps and parts of the container disclosed in the aforesaid European Patent to "Odobez", which can be regarded as the closest to the invention,

- Fig. 1c is a diagram showing the steps and parts of the invention,

- Fig. 2 is a first side view,

- Fig. 3 is a first plan view,

- Fig. 4 is a second side view,

- Fig. 5 is a second plan view,

- Fig. 6 is a third side view,

- Fig. 7 is a third plan view,

- Fig. 8 is a fourth side view.

With reference to the diagrams in Figs. 1a, 1b and 1c the following abbreviations are used:

- N is the neutralization step,

- V1 is the first treatment step (DE-NITRO),
- V2 is the second treatment step (NITRO),
- SF is sludge separation,
- RF is sludge recirculation,
- FS is sludge discharge.

5

The figures show that for implementing steps N, V1, V2, SF generally four tanks are required in plants prior to Odobez, two tanks in Odobez plant, and that in the plant according to the invention only one tank is required for steps N, V1, V2, RF and SF, whereas sludge discharge takes place directly from the only tank. The aeration container, if present, is regarded as part of the processing tank.

10

- Figs. 2 and 3 show a plant without biomass control. Sewage or effluent from outside is poured into the tank 1 in IN. The figure shows that (in the first process step) a pump 2 sucks up sewage or effluent from the bottom of the tank through the ducts 3, 6 and the mechanical self-cleaning filter 4, whose purpose is to keep the pump 2 and the oxygenizers 5 clean retaining coarse material that may be present in the effluent or sewage, discharged through the pipe 4a. Treated sewage or effluent is daily sucked up by the pump 12 through the duct 15 and discharged through the duct 16 (OUT). The same pump 2 presses the sewage or effluent in the upper pipe network 7 comprising a plurality of cross ducts 8 deriving from the pipe 7. The pressure of the pump 2 is controlled within a predefined range by means of a control panel receiving signals of process parameters through probes. The central duct 7 gets into the upper region of the tank and through it along the longitudinal middle axis. L refers to the surface of the liquid in the tank. A plurality of cross ducts 8 starts from the duct 7, which ducts send the sewage or effluent to a plurality of oxygenizers 5, each equipped with a pipe 9 extending and opening into the atmosphere. The oxygenizers 5 pour into

15

20

25

the tank 1 sewage or effluent mixed with air sucked up by “Venturi effect” through the pipes 9. The oxygenizers 5 are inclined so that their stream can reach the bottom of the tank. A mechanical stirrer 10 is installed near the bottom of the tank so as to be activated with its propeller 11 (in the second process step). A lower pipe network sucking up sewage or effluent from the bottom of the tank starts from the intake duct 3 where it enters the tank and includes the branches 3a, 3b, 3c, each equipped with intake openings 13 forming a plurality of intake openings distributed on the bottom of the tank. The cross ducts 8 and the plurality of oxygenizers 5 are divided into two groups with respect to the longitudinal middle axis X-X. A group of oxygenizers faces a longitudinal direction and the other group faces the opposite longitudinal direction, this in order to increase fluid stirring inside the tank in the first process step. In the example shown, the tank is rectangular in plan, with a surface of 340 m² and an effective height of 3.5 m. The pump 2 can pump into the upper pipe network 350 m³/h of sewage or effluent, at an average pressure of 7 bars (the range being 6-9 bars) in case of refractory effluent, and at an average pressure of 4 bars (the range being 3.5-5.5 bars) in case of zootechnical sewage (though with a larger number of oxygenizers), so that the whole of the oxygenizers 5 supplies a flow rate of effluent or sewage and air of 850 m³/h; the plant thus sized is able to treat a refractory polluted water with 1,500 kg COD/day and 150 kg TKN/day reducing nitrogen load (TKN) of 85% and organic load (COD) of 80% (COD = Chemical Oxygen Demand; TKN = Total Kjeldahl Nitrogen). Under the above conditions the value of the coefficient k (see previous formula) for sewage is $k = 60$ and for effluent $k = 90$. Thus, applying the formula for calculating the distance D from the bottom of the tank for sewage, the discharge openings of the 480 oxygenizers will be located at 1.25 m from the bottom of the tank and the oxygenizers will be oriented towards the bottom at 31° (considering the horizon =

0°), for effluent the discharge openings of the 330 oxygenizers will be located at 1.65 m from the bottom and the oxygenizers will be oriented towards the bottom at 42° (considering the horizon = 0°). It can be inferred that the processing tank can be of any shape in plan, depending on the characteristics of the site in which it is installed, e.g. beyond being rectangular, it can be square, circular, polygonal in plan.

- Figs. 4 and 5 show a plant as in Figs. 2 and 3, though equipped with an inner clarifier 17 in which the sludge produced during the process is collected and directly recirculated in the tank 1 or sent to the excess sludge by means of the pump 12a (FS). Treated water is discharged through the drain 18 and the pipe 19 (OUT).

- Figs. 6 and 7 show a plant as in Figs. 2 and 3, though equipped with a series 20 of micro-or ultrafiltration membranes inside the processing tank, in which the sludge produced during the process is filtered and directly recirculated in the tank 1 or sent to the excess sludge by means of the pump 12b (FS). Treated water is extracted through the pump 12c and the pipe 19a (OUT).

Fig. 8 shows a plant as in Figs. 6 and 7, though equipped with a system comprising an atmospheric air suction fan 22 (arrows f) and an air duct network, globally referred to with numeral 23, branched and connected to each of the pipes 9 of the oxygenizers 5 so that the latter receive an air surplus and strongly oxygenate the sewage or effluent in the processing tank 1. OUT refers to the extraction of treated water through a pump (not shown).

Figs. 9 and 10 show a first plant with a closed aeration container 24 outside the processing tank 1. An oxygenation pump 25 takes sewage or effluent from the processing tank through a mechanical filter 44 and the pipes 26 and supplies it at high pressure in the pipe 27 into the same aeration container equipped with a suitable number of oxygenizers 5a. The sewage or effluent thus aerated is supplied back into the

bottom of the processing tank by gravity along the pipes 28 (optionally by means of a pump not shown), in which processing tank stirring occurs by way of a mechanical stirrer 10a. The extraction (OUT) of treated water is still carried out by means 12, 15, 16 already mentioned with reference to Figs. 2 and 3.

5 Figs. 11 and 12 show a second plant with a closed aeration container 24a outside the processing tank 1. An oxygenation pump 25a takes sewage or effluent from the aeration container through a mechanical filter 44a and the pipes 26a and supplies it at high pressure in the pipe 27a into the same aeration container equipped with a suitable number of oxygenizers 5b, each associated to an intake pipe 9a. The pump
10 30 supplies continuously the aeration container with new sewage or effluent to be aerated through the pipe 32 from the processing tank by way of the pipe 21, whereas the effluent or sewage thus aerated is supplied back into the bottom of the processing tank by gravity along the pipe 28a (optionally by means of a pump not shown), in which processing tank stirring occurs by way of a mechanical stirrer 10b. The extraction
15 (OUT) of treated water is still carried out by means 12, 15, 16 already mentioned with reference to Figs. 2 and 3.

Claims

1. A process for purifying polluted waters in a processing tank with continuous supply and discharge, in which two steps alternate, a first nitrification step and a second de-nitrification step, in the first step sewage or effluent and air being blown with conventional oxygenizers installed along a pipe network and equipped with means for sucking up atmospheric air thanks to an effect only conventionally here referred to as "Venturi effect", alternating times and step duration being selected as a function of nitrogen load being input, and the process being **characterized** in that in the first step the pressure in the pipe network is kept above 2 bars and a mixture of air and sewage or effluent is blown by means of the oxygenizers into the tank at a distance D from the bottom of the tank varying from about half the effective height of the tank to about the surface of the liquid in the tank, and in the second step the sewage or effluent treated in the first step is stirred without blowing air by means of at least one stirrer that is able to break the biological foam previously formed.

2. The process according to claim 1, characterized in that said distance D from the bottom of the tank is defined by the function $D = \log_a x$, wherein $a = (x^4 + x^3)/k$, x is the effective height of the tank and k is an empirical constant depending on the type of effluent or sewage and on the type of treatment or purification used.

3. The process according to claims 1-2, characterized in that the aeration required in the first process step is obtained in a closed container independent from the processing tank, and in that a continuous recirculation of sewage or effluent is obtained between the processing tank and the closed container, which recirculation distributes the flow of aerated sewage or effluent in the whole volume of the processing tank.

4. The process according to claims 1-3, characterized in that for the

treatment of sewage it is possible to keep in the first step dissolved oxygen (DO) and redox potential (RedOX) in which $DO < 0.1 \text{ mg/l}$ and $RedOX = -200 \text{ m} \div 0 \text{ mV}$ thanks to the high concentration of dissolved oxygen and positive redox inside the oxygenizers, and the second step is characterized by conditions in which $DO = 0 \text{ mg/l}$ and RedOX = $-400 \div 300 \text{ mV}$, thus causing a reduction of about 85% of nitrogen and of about 80% of organic substance.

5 5. The process according to claims 1-4, characterized in that the average pressure in the pipe network is of about 4 bars in processes for the treatment of sewage.

10 6. The process according to claims 1-4, characterized in that the average pressure in the pipe network is of at least 7 bars in processes for the treatment of effluents.

15 7. A plant for purifying polluted water according to the process claimed in claims 1-6, comprising a processing tank receiving from outside the polluted sewage or effluent, at least one pump sucking up sewage or effluent from the bottom of the tank and sending it into a pipe network including a plurality of oxygenizers immersed in the sewage or effluent, a filter being placed between the pump and a pipe sucking up the sewage or effluent from the bottom of the tank, and characterized in that the pump produces in the pipe network a pressure of at least 2 bars and the discharge openings of the oxygenizers are located at a distance D from the bottom of the tank varying from about half the effective height of the tank to the surface of the sewage or effluent in the tank.

20 8. The plant according to claim 7, characterized in that said distance D from the bottom of the tank is defined by the function $D = \log_a x$, wherein $a = (x^4 + x^3)/k$, x is the effective height of the tank and k is an empirical constant depending on

25

the type of effluent or sewage and on the type of treatment or purification used.

9. The plant according to claims 7-8 characterized in that the pump creates in the pipe network an average pressure of about 4 bars in processes for the treatment of sewage.

5 10. The plant according to claims 7-8 characterized in that the pump creates in the pipe network an average pressure of about 7 bars in processes for the treatment of effluents.

10 11. The plant according to claims 7-10, characterized in that the oxygenizers are installed with their discharge axis inclined of 8° to 90° with respect to the horizontal.

12. The plant according to claims 7-11, characterized in that it comprises:

a) a closed aeration container, associated to and outside or inside the processing tank, in which a plurality of oxygenizers is located and sewage or effluent is aerated during the first process step,

15 b) the pump taking the sewage or effluent from the processing tank and supplying it under high pressure into an oxygenation network and transferring it by means of oxygenizers into the closed aeration container from which the sewage or effluent thus aerated is supplied back into the bottom of the processing tank where a stirrer carries out the stirring of the second process step.

20 13. The plant according to claims 7-11, characterized in that it comprises:

a) a closed aeration container, associated to and outside or inside the processing tank, in which a plurality of oxygenizers is located and sewage or effluent is aerated during the first process step,

25 b) the pump taking the sewage or effluent from the aeration container and supplying it back under high pressure into an oxygenation network and transferring it

by means of oxygenizers into said container, and a second pump taking from the bottom of the processing tank the sewage or effluent to be aerated and sending it to the closed aeration container, the effluent or sewage thus treated being supplied back into the bottom of the processing tank where a stirrer carries out the stirring of the second process step.

14. The plant according to claims 7-13, characterized in that it comprises forced blowing means that are able to send pressurized air into the oxygenizers, thus increasing the flow rate of air sucked up by "Venturi effect".

15. The plant according to claims 7-14, characterized in that the processing tank is equipped with at least one inner clarifier in which settles the sludge produced and to be extracted or recirculated.

16. The plant according to claims 7-14, characterized in that the processing tank is equipped with microfiltration or ultrafiltration membranes for filtering the sludge produced and to be extracted or recirculated.

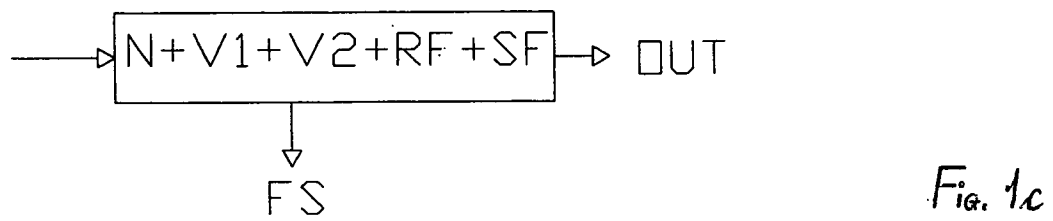
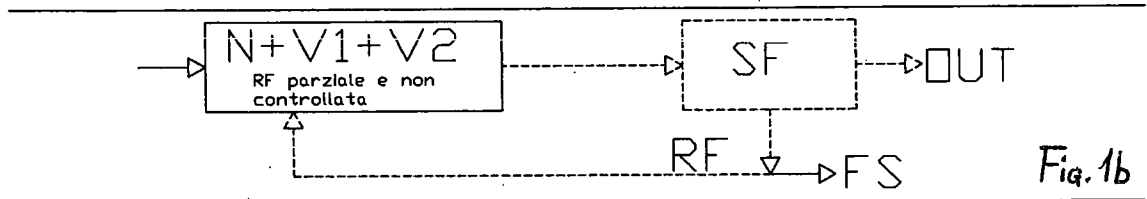
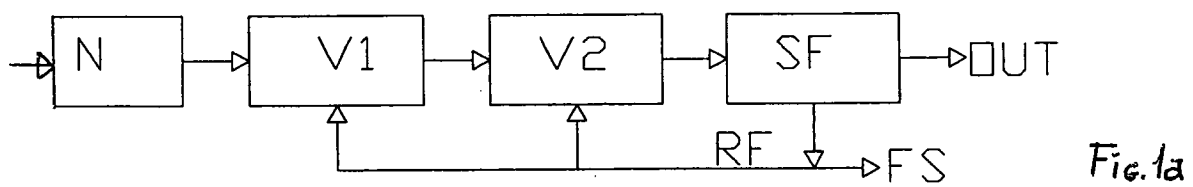


FIG. 3

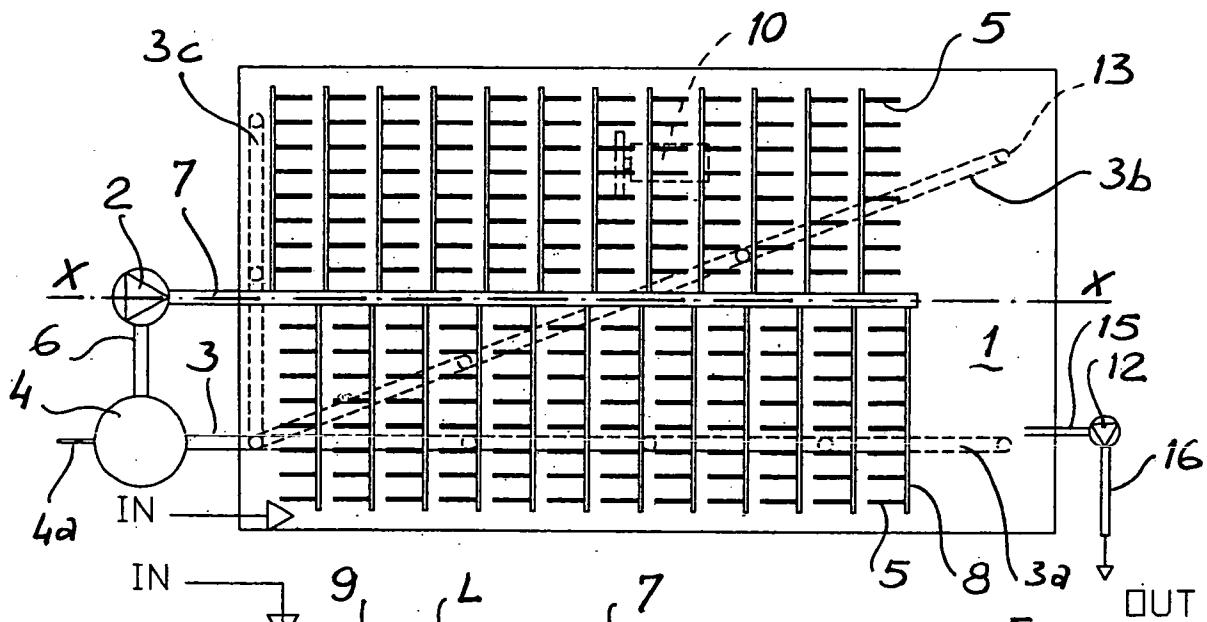


FIG. 2

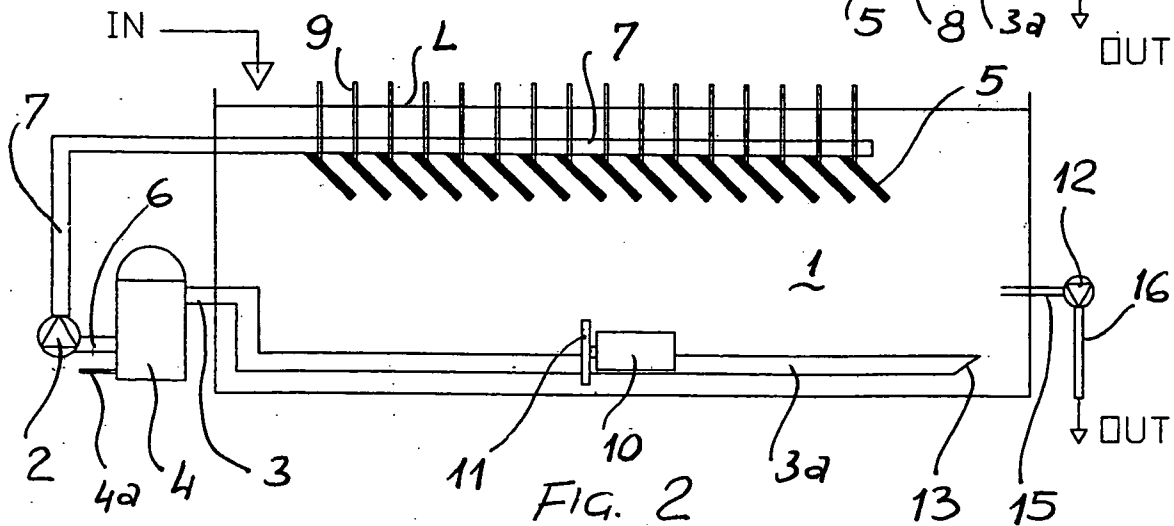


FIG. 5

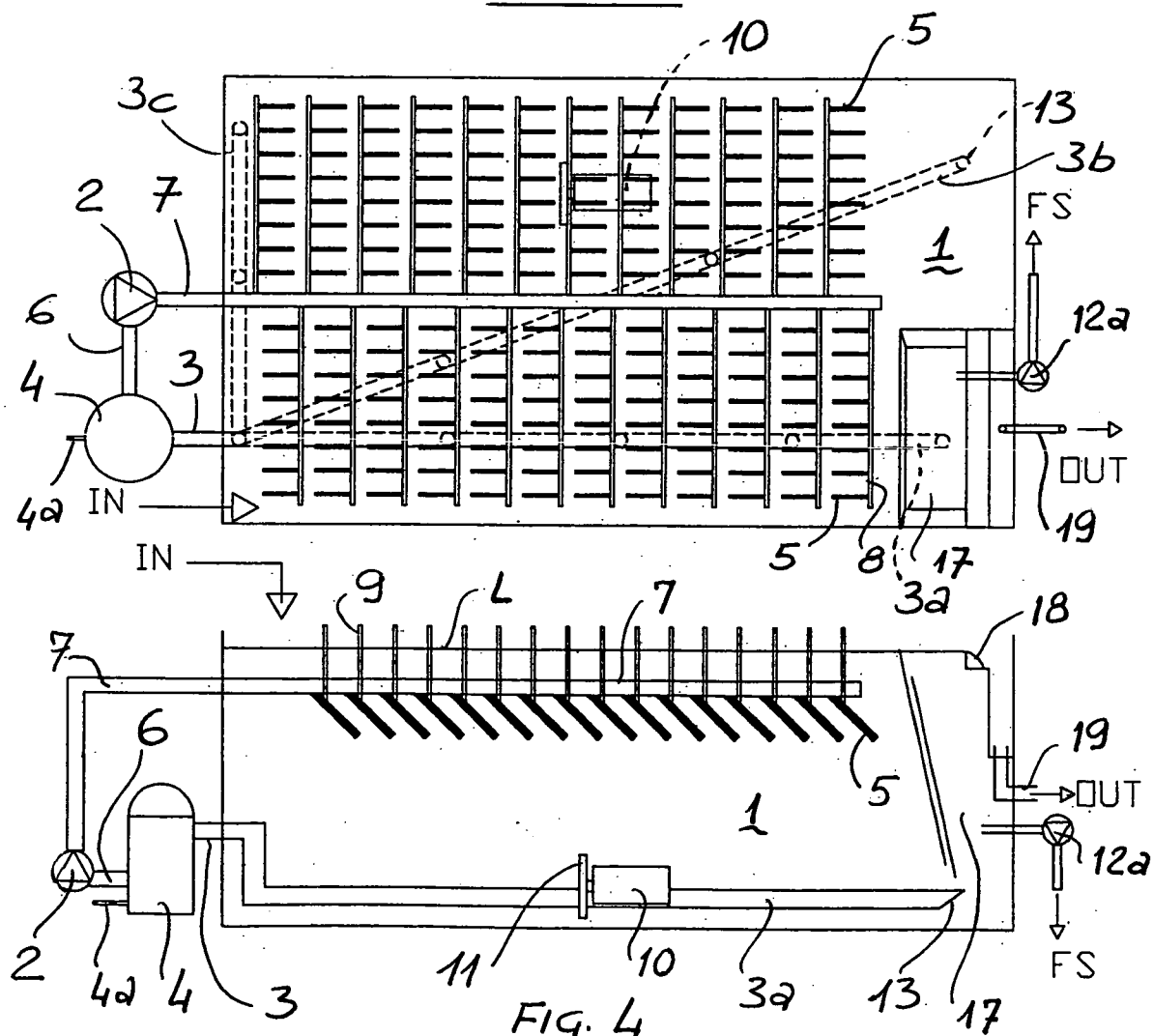


FIG. 7

