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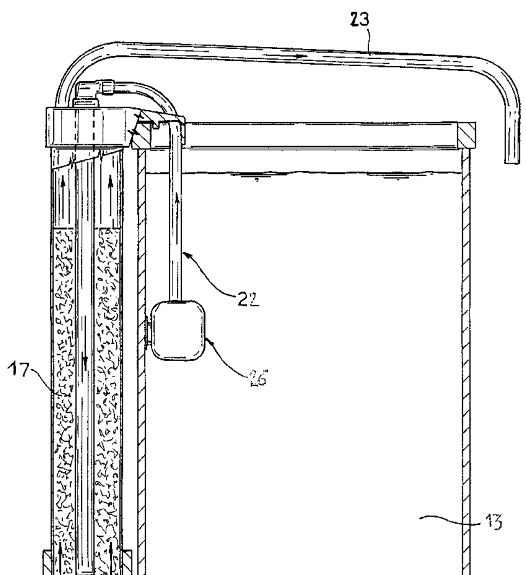
(54) Title: WATER PURIFICATION PROCESS AND PURIFICATION PLANT



(57) Abstract: The water purification process, in particular for the conditioning of water or for the breeding of aquatic organisms, includes the step of transforming inorganic nitrogenous compounds using a composition including manganese dioxide. In particular, the manganese dioxide is present in a biological filter which includes bacteria able to transform the organic nitrogenous products into inorganic nitrogenous products and oxidize the latter into nitrates.

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WATER PURIFICATION PROCESS AND PURIFICATION PLANT

TECHNICAL FIELD

The present invention concerns a water purification process and relative purification plant, in particular by the oxidation of inorganic nitrogenous compounds.

BACKGROUND ART

Nitrogenous compounds are generally considered as water polluting and, during the water purification process, an oxidation step or the elimination of such compounds is therefore necessary by transformation into non-polluting nitrates, according to the following reactions:

(1) $NH_4^+ + 1.5\ O_2 \rightarrow 2H^+ + H_2O + NO_2^-$

(2) $NO_2^- + 0.5O_2 \rightarrow NO_3^-$.

For this purpose, a process is known to treat the organic nitrogenous compounds with biological filters which contain bacteria capable of turning the nitrogenous compounds into inorganic nitrogenous compounds, namely ammonia and nitrites and thus oxidize the inorganic nitrogenous products into nitrates.

Such filters are more vulnerable and less efficient in the treatment of inorganic nitrogenous compounds and also extremely sensitive to chemical-physical type environmental fluctuations.

In particular, the efficiency of the biological filters varies considerably with temperature and pH (the oxidation efficiency is considerably reduced at low or high values).

The biological filters normally include heterotrophic and autotrophic bacteria. The heterotrophic bacteria are able to turn the organic nitrogenous compounds into ammonia, while the autotrophic bacteria oxidize the ammonia into nitrites, and the nitrites into nitrates, which are not considered as polluting. In particular, the ammonia is generally oxidized into nitrites by numerous families of autotrophic bacteria, among which, for example, are the nitrosomonas and the nitrites are afterwards oxidized into nitrates by other kinds of bacteria, among which, for example, are the Nitrobacteria.

Since the heterotrophic bacteria need carbon based compounds to function correctly, whereas autotrophic ones need inorganic azote, the water quality, measured as oxygen demand in the form of carbonaceous compounds, influences the transformation capacity of the nitrogenous compounds. The result is that the heterotrophic bacteria generally grow at a greater speed than autotrophic bacteria or nitrosomes and thus is difficult for nitrobacteria to achieve the elimination of organic nitrogenous compounds by transformation into inorganic nitrogenous compounds, more quickly, and with the slower transformation of inorganic nitrogenous compounds into non-polluting nitrates in the same filters in a single step .

It is therefore necessary to proceed with the biological treatment, which is able to only partially oxidize the inorganic nitrogenous compounds, an oxidation treatment using chlorine or ozone able to complete the oxidation of such residual compounds. This water purification process occurs in two separate step s. Moreover, in the particular case of the breeding of aquatic organisms, it is impossible to use purification plants in which one proceeds with a total oxidation of the substances present, with chlorine or ozone, since such substances prove toxic for the aquatic organisims themselves, even at low percentages.

For example, a known purification plant for the elimination of nitrogenous compounds deriving from metabolites in an aquatic organism farm can consist of a main purification circuit for the partial conditioning of all the water in tanks where the fish are bred and a secondary or lateral purification circuit for the total conditioning of part of the water, able to increase the total purity degree of the water. The main purification circuit includes a drum filter or sand filter to hold back the large particulate and a biological filter for the removal of nitrogenous compounds arising from metabolic activity which presents the aforesaid problems.

In addition, part of the water undergoes further purification treatment through the secondary purification circuit which essentially includes an ozonization step . Ozone is a strong oxidizer and is therefore able to eliminate the additional fine particulate in the water by oxidising it. However, such treatment proves very expensive and besides, as already mentioned, the ozone is toxic for the aquatic organisms, also in small amounts. Hence it is impossible to extend the ozonization treatment to all the water to be purified. It would therefore be desirable to be able to avoid the introduction, into the water purification process, of the treatment step with ozone in the breeding of aquatic organisms and reduce the amount of chlorine used in the conditioning process.

The known water purification plants are therefore complex and expensive and the purification process needs many step s and, on the whole, optimum efficiency is not achieved.

DISCLOSURE OF INVENTION

Therefore the aim of the present invention is to achieve a water purification process and a relative plant which solves the aforesaid drawbacks and which is more efficient and reliable also at different pH and temperature values, able to maintain high efficiency also in the case of rapid growth of the inorganic nitrogenous compounds themselves and, in particular, that it is simpler and hence less expensive.

Another aim of the present invention is besides to produce a water purification plant for the conditioning process.

A third aim of the present invention is to produce a water purification plant for the breeding of aquatic organisms.

According to the present invention a water purification process is achieved including the transformation step of inorganic nitrogenous compounds, characterised in that said transformation step of the inorganic nitrogenous compounds includes the step to treat said water with a composition which includes manganese dioxide.

According to the present invention a water purification plant is besides achieved which includes transformation means of inorganic nitrogenous compounds, characterised in that said transformation means of inorganic nitrogenous compounds include manganese dioxide.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, a water purification plant will now be described in detail, supplied simply as an explanatory, non-limiting example, also with reference to the enclosed designs, which show:

- Figure 1 is a block diagram of a purification plant produced according to the present invention; and
- Figure 2 is a partial view of a detail of the water purification plant in figure 1.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to the block diagram in figure 1, 9 denotes, as a whole, a water purification plant for the breeding of aquatic organisms including a breeding tank 11 for the aquatic organisms, a drum filter 12 for the elimination of the coarse particulate, a dirty water collection tank 13, a purified water tank 14, a biological filter 15, a second drum filter 16 and a filter 17 containing manganese dioxide.

In the purification plant 9, the water contained in the breeding tank 11 flows towards a drum filter 12 for the removal of the larger particulate. Hence, the water is conveyed into the dirty water tank 13.

Afterwards, part of the water can be taken from the dirty water tank 13 and filtered through a biological filter 15.

A percentage of the water is then taken from the dirty water tank 13 (figure 2) by pump 26 depending on the final purity desired, and is made to pass through the tube 22 and introduced into the filter 17 containing manganese dioxide and thus it exits towards the purified water tank 14 through tube 23. A drum filter 16 can be placed between the dirty water tank 13 and the filter 17, if necessary (figure 1).

In particular, the filter 17 includes grains of sand and manganese dioxide as support material, preferably in amounts of between 15-25% in volume, calculated on the total volume of filter 17.

The manganese dioxide used in the present invention has a granulometry which varies according to the various plants.

Preferably, since the manganese dioxide is, on average, heavier than the grains of sand the manganese dioxide is added in granular form so as to ensure uniform mixing along the whole thickness of the filter.

However it is also possible to use the manganese dioxide without support material, for the oxidization of inorganic nitrogenous compounds for example in semi-intensive farms, as in ponds or similar.

In any case, the regeneration of the manganese dioxide necessary in filters in which it is used for other purposes is superfluous, according to the present invention, since in this case it does not have an oxidizing function and is thus not reduced.

Table 1 contains an example of a filter 17 containing manganese dioxide usable in a water purification plant 9 as previously described.

Table 1

Average size of grade 16/30 grains of sand	0.595-1.19mm
Size of grade 18/44 manganese dioxide	0.355-0.85mm
Ratio between sand and manganese dioxide	80%:20%
Bed size	16 m^2
Bed depth	0.1m
Flow speed	65 m^3/hour
Speed	4.1m/hour
Contact time	21min.
Filter duration prior to washing	1-2 days
Water consumption for the washing	6-8%
Washing flow speed	1.7 m^3/min
Water flow speed	0.11m/min.

Table 2 contains an example of a purification plant 9 according to the present invention.

Table 2

Total plant volume	1050M^3
Fish tank 1	800M^3
% of total plant volume	76%
Tank for dirty water collection 3	14M^3
Tank for purified water collection 4	14M^3
Biological filter 5	11M^3
Sand filter with MnO2 7 (40%)	27M^3
Very pure water collection tank	136M^3
Volume of treatment unit	250M^3

% of total volume	24%
Degree of recirculation	
New water introduced in the plant	3 l/s
Maximum flow speed	120 l/s
% Recirculation = (recirculated flow/ total flow) (%)	97.5%
Water replaced per day	259M³/day
% per day compared to total water	24.8%

Mean water staying time in the purification plant 4 days

Table 3 contains data obtained from water samples taken from a purification plant 9 and relative to the oxidation of ammonia and nitrites. Each of the 26 samples was taken on a different date and the table contains the water temperature at the moment of measurement (Temp.) in centigrade, the pH of the water flow entering into the sand filter, the contact time of the water with the filter, the ammonia content before treatment (NH3 b.t.) and the ammonia content after treatment (NH3 a.t.), the efficiency of the oxidation treatment of the ammonia with a sand filter containing manganese dioxide where CBT is the NH3 concentration before treatment and CAT is NH3 concentration after treatment.

Table 3

Sample number	1	2	3	4	5	6
Temperature. (C)	9.3	11.2	11.1	11.7	14.5	12.8
PH entry flow	7.45	6.4	6.5	6.9	6.8	6.6
Contact time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
NH4+ p.T (mg/l)	0.11	0.42	0.51	0.37	0.5	0.61
NH3N+ d.T (mg/l)	0.01	0.05	0.01	0.02	0.04	0.02

Efficiency (1-CAT/CBT)	0.91	0.88	0.98	0.95	0.92	0.97
NO2-p.T (mg/l)	0.004	0.028	0.04	0.042	0.105	0.183
NO2-d.T (mg/l)	0	0.007	0	0	0.004	0.027
Efficiency (1-CAT/CBT)	1.00	0.75	1.00	1.00	0.96	0.85
Sample number	7	8	9	10	11	12
Temperature. (C)	16	14.7	13.2	14.3	15.1	12.4
PH entry flow	6.5	6.6	6.5	6.5	6.6	6.5
Contact time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
NH3 p.T (mg/l)	1.24	1.18	0.86	1.13	1.00	0.96
NH3 d.T (mg/l)	0.05	0.04	0.07	0.05	0.05	0.03
Efficiency (1-CAT/CBT)	0.96	0.97	0.92	0.95	0.95	0.97
NO2-p.T (mg/l)	0.160	0.231	0.205	0.325	0.271	0.189
NO2-d.T (mg/l)	0.036	0.009	0.001	0	0	0
Efficiency (1-CAT/CBT)	0.78	0.96	1.00	1.00	1.00	1.00
Sample number	13	14	15	16	17	18
Temperature. (C)	14.2	12.6	11.3	10.1	5.7	4.6
PH entry flow	6.6	7	6.9	6.3	7.52	7.35
Contact time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
NH3 p.T (mg/l)	0.74	0.81	0.72	0.76	0.25	0.34
NH3 d.T (mg/l)	0.05	0.03	0.05	0.06	0	0
Efficiency (1-CAT/CBT)	0.93	0.96	0.93	0.92	1.00	1.00
NO2-p.T (mg/l)	0.173	0.155	0.079	0.990	0.032	0.055
NO2-d.T (mg/l)	0	0	0	0.001	0	0
Efficiency (1-CAT/CBT)	1.00	1.00	1.00	1.00	1.00	1.00

Sample number	19	20	21	22	23	24
Temperature. (C)	15.6	14.5	17.4	15.1	15	15.4
PH entry flow	6.77	6.78	6.71	6	6.5	6.2
Contact time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
NH3 p.T (mg/l)	0.53	0.31	0.68	0.68	0.8	0.85
NH3 d.T (mg/l)	0.02	0.02	0.04	0.08	0.04	0.04
Efficiency (1-CAT/CBT)	0.96	0.94	0.94	0.88	0.95	0.95
NO2-p.T (mg/l)	0.08	0.20	0.20	0.21	0.26	0.102
NO2-d.T (mg/l)	0.014	0.001	0.028	0.019	0.016	0.003
Efficiency (1-CAT/CBT)	0.93	0.99	0.86	0.91	0.94	0.97

Table 4 contains the data relating to the oxidization efficiency of a filter 17 including manganese dioxide compared with an identical filter without manganese dioxide.

Table 4

Filter features:	
Mean Vol. (m3)	0.0002
Section diameter (m)	0.035
Area (m2)	0.0010
Depth of the fluid bed (m)	0.2
Flow (m3/hr)	0.086
Flow, m3*hr/m2	89
Flow, m3*hr/m3mean	430
Speed (m/hr)	89
Retention time (sec.)	8
Temperature (C)	9.8
pH	6.8
DO (mg/L)	7.4
NH4-N B.T (mg/l)	0.84
NO2-N B.T (mg/l)	0.23

Tot. Mn B.T (ug/l)	4.3
Filter with 16/30 content without manganese dioxide	
NH4-N A.T (mg/l)	0.85
Efficiency (1-(CAT/CBT))	-0.02
NH4-N removal(g/d)	-0.03
NH4-N removal(g/d/m3)	-162
NO2-N A.T (mg/l)	0.257
Efficiency (1-(CAT/CBT))	-0.12
Removal NO2-N (g/d)	-0.06
Removal NO2-N (g/d/m3)	-289
16/30 filter + 20% (in volume) MnO2 grade 18/44	
NH4-N A.T (mg/l)	0.81
Efficiency (1-(CAT/CBT))	0.03
NH4-N removal(g/d)	0.05
NH4-N removal(g/d/m3)	265
NO2-N A.T (mg/l)	0.241
Efficiency (1-(CAT/CBT))	-0.05
Removal NO2-N (g/d)	-0.02
Removal NO2-N (g/d/m3)	-124
Tot. Mn Out (ug/L)	4.1

With a purification plant, according to the present invention, it is therefore possible to achieve a degree of efficiency, for that concerning the oxidization of ammonia, of around 90% whereas a conventional biological filter has a degree of efficiency of 30-40%.

Filter 17 may also be used inside a water purification plant for conditioning. Due to the greater purity of the water exiting from filter 17, which contains a percentage of residual inorganic nitrogenous compounds which is less than that in known purification systems, it is possible to avoid or, at least, reduce the treatment of water with chlorine or ozone, as in fact occurs, in the normal purification plants for the breeding of aquatic organisms or for the conditioning process.

It is clear that modifications and variations may be made to the purification plant herein described and illustrated without leading away from the protective scope of the present invention.

CLAIMS

1. A water purification process including the transformation step of inorganic nitrogenous compounds, characterised in that said transformation step of inorganic nitrogenous compounds includes the step of treating said water with a composition which includes manganese dioxide.

2. A water purification process according to claim 1, characterised in that said step of treating said water with manganese dioxide is preceded by a step of transforming organic nitrogenous compounds into inorganic nitrogenous products.

3. A water purification process according to claim 2, characterised in that said step of transforming said organic nitrogenous compounds is carried out by bacteria.

4. A water purification process ccording to any one of claims 2 or 3, characterised in that said step of transforming said organic nitrogenous compounds and said step of transforming said inorganic nitrogenous compounds take place in the same step inside a biological filter.

5. A water purification process according to any one of the previous claims for the breeding of aquatic organisms.

6. A water purification process according to any one of the previous claims for water conditioning.

7. A water purification process for the breeding of aquatic organisms according to claim 5, characterised in that said composition includes a support material.

8. A water purification process for the breeding of aquatic organisms according to claim 7, characterised in that said support material is sand.

9. A water purification process for the breeding of aquatic organisms according to claims 7 or 8, characterised in that said manganese dioxide is present in an amount between 5 and 25% in volume compared to said support material.

10. A water purification process for the breeding of aquatic organisms according to any one of claims 6 to 9, characterised in that said manganese dioxide is contained in a sand filter.

11. A water purification process for the breeding of aquatic organisms according to any one of the claims 7 to 10, characterised in that said manganese dioxide is present in granular form.

12. A water purification process for the breeding of aquatic organisms according to any one of the claims 7 to 11, characterised in that said step to treat nitrogenous compounds includes the step to directly add manganese oxide to water.

13. A water purification plant including transformation means of inorganic nitrogenous compounds, characterised in that said transformation means of inorganic nitrogenous compounds include manganese dioxide.

14. A water purification plant including transformation means of inorganic nitrogenous compounds as in claim 13, characterised in that it also includes treatment means of organic nitrogenous compounds into inorganic nitrogenous products.

15. A water purification plant including transformation means of inorganic nitrogenous compounds as in claim 14, characterised in that said treatment means of organic nitrogenous products include bacteria.

16. A water purification plant including transformation means of inorganic nitrogenous compounds as in claim 15, characterised in that said treatment means of organic nitrogenous compounds and said transformation means of inorganic nitrogenous compounds are immersed in the same container.

17. A water purification plant including transformation means of inorganic nitrogenous compounds according to any one of the claims 13 to 16, for water conditioning.

18. A water purification plant including transformation means of inorganic nitrogenous compounds according to any one of the claims 13 to 16, for the breeding of aquatic organisms.

19. A water purification plant including transformation means of inorganic nitrogenous compounds according to claim 18, characterised in that said transformation means of inorganic nitrogenous compounds include a support material.

20. A water purification plant according to claim 19, characterised in that said support material is sand.

21. A water purification plant according to claim 20, characterised in that said manganese dioxide is present as 5 to 25% in volume compared to said sand.

22. A water purification plant according to any one of the claims 21 to 22, characterised in that said manganese dioxide is present in granular form.

23. A water purification plant according to claim 22, characterised in that said granules are of mean size of between 0.595 and 2mm.

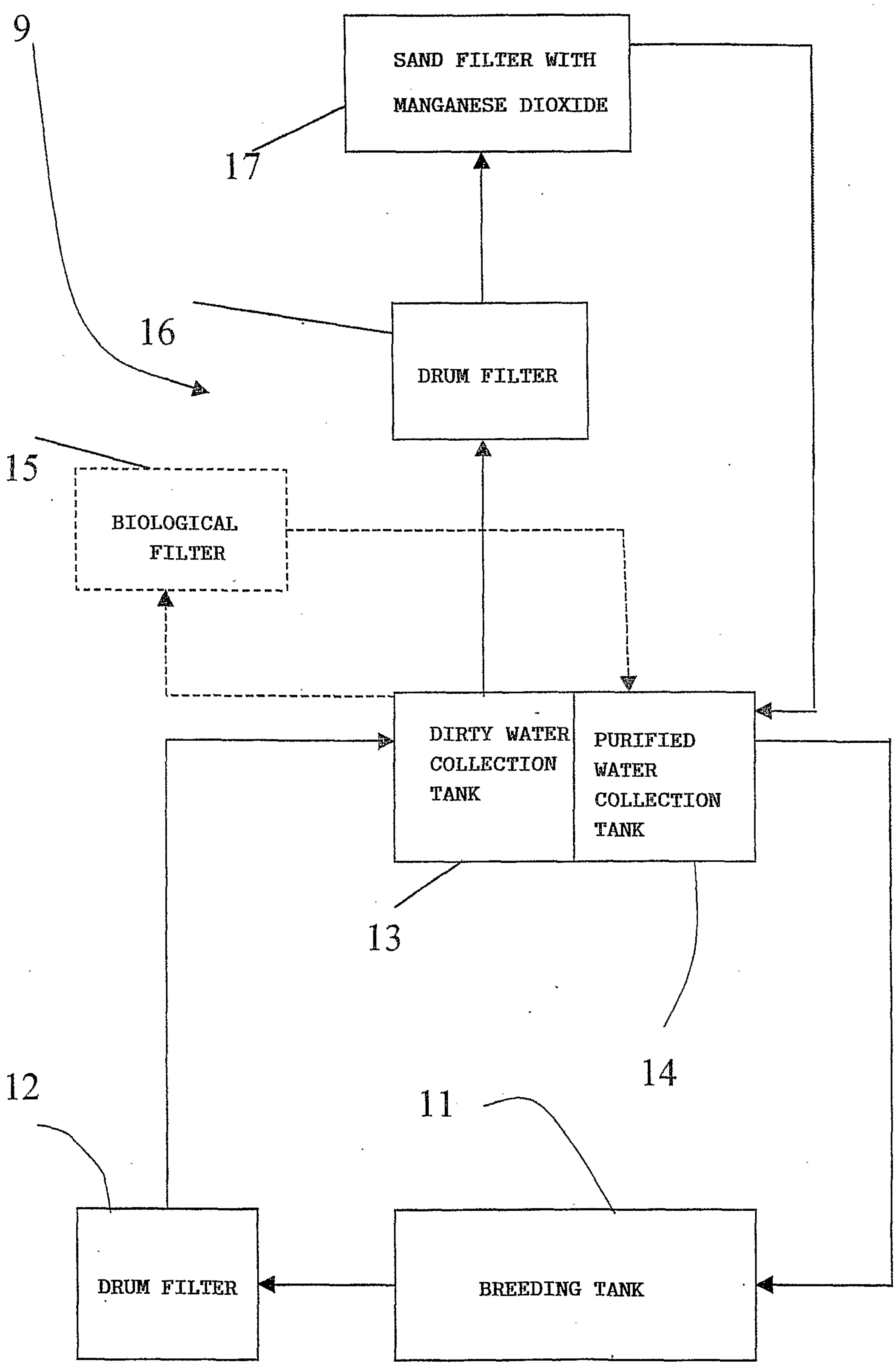
9
SAND FILTER WITH MANGANESE DIOXIDE
17
16
DRUM FILTER
15
BIOLOGICAL FILTER
DIRTY WATER COLLECTION TANK
PURIFIED WATER COLLECTION TANK
13
14
12
11
DRUM FILTER
BREEDING TANK

Fig. 1

Fig.2