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RAFFAELLO COSSU*

BIOLOGICAL REMOVAL OF NITROGEN FROM LOW CONTENT BOD SEWAGE BY SIMULTANEOUS NITRIFICATION-DENITRIFICATION PROCESS

Results of investigations on biodegradation of municipal sewage with low BOD content, involving a simultaneous removal of nitrogen compounds, have been presented. The process studied has required an appropriate choice of rotors operational conditions under which the alternating aerobic and anaerobic zones have been obtained. In these zones nitrification and denitrification processes take place, respectively. At total nitrogen content and COD in the inlet ranging from 10 mg N/dm^3 to 28 mg N/dm^3 and 100 mg O_2/dm^3 to 200 mg O_2/dm^3, respectively, the total nitrogen content in the outlet amounted to 5–6 mg N/dm^3.

1. INTRODUCTION

Biological removal of nitrogen from wastewaters by simultaneous nitrification–denitrification process is based, as is well known, on the alternate formation of anoxic and aerated areas inside the same plug flow activated sludge basin, in which the mixed liquor is put into circulation by mechanic aerators, like fixed turbines or rotating brushes. In the aerated zone upstream from the aerator, both the oxidation of the organic substances and nitrification take place. The metabolic O_2 consumption, which occurs in this zone, determines the formation of the following anoxic area, in which the denitrification takes place and which extends up to the subsequent aerator. From this point a new aerated zone is developed, and so forth. This type of process, applied on the full scale a certain number of times, is usually related to working alterations carried out on the already existing plant, not specifically designed for nitrogen removal.

* Institute of Sanitary Engineering, Polytechnic of Milan, Faculty of Industrial Chemistry, University of Venice, Italy.

In 1964 Pasveer studied the possibilities of an efficient nitrogen removal in activated sludge basins of the oxidation ditch type, along with the reduction of the capacity of the aerators.

In more recent times the most significant experiments with this kind of process have been carried out in Austria at the Vienna-Blumental plant [4, 6, 7] and in Holland at the Winterswijk plant [5].

In these experiments the total nitrogen removal has yielded in Vienna under the best working conditions the value of 88%, and at Winterswijk an average value of 77%.

In both the cases BOD concentrations in the raw sewage exceeded 200 mg/dm^3, reaching 700 mg/dm^3 at the Winterswijk plant, where industrial wastewaters from the beer industry were also fed.

So far, however, the applicability of the simultaneous nitrification–denitrification process to diluted sewage with daily varying polluting loads is not known.

This situation, which is fairly common, has also been found in the case of sewage coming from the Venetian mainland and can be justified by the following reasons:

high water consumption,

development of the sewer network below the ground water level, with the consequent definite contributions of white waters,

equipment of a large percentage of the houses with septic tanks and further reduction of the organic load fed into plant.

These reasons, as shown by studies on the complete denitrification process [1, 2], determine insufficiencies of the process due to the lack (in those hours of the day in which the sewage is more diluted) of the BOD/N ratio used in denitrification and the minor metabolic consumption of oxygen which can make difficulte reaching the anoxic conditions in the denitrification stage.

2. DESCRIPTION OF THE EXPERIMENTAL PLANT

The plant, which was built and put into operation in 1976, serves a part of the population inland from Mestre. It has been designed for 33,000 inhabitants, but actually it serves 20,000.

The lay-out of the plant is shown in fig. 1. The biological oxidation by activated sludge is carried out in two parallel aeration basins, each equipped with a couple of brush type superficial aerators.

As shown in tab. 1, in which various working units and the project data for the plant are specified, the plant has been planned so as to work under total oxidation conditions with complete stabilization of the sludge.

For the above reasons the plant has been designed to operate without digestors or other units for the mineralization of the sludge and without the primary sedimentation.

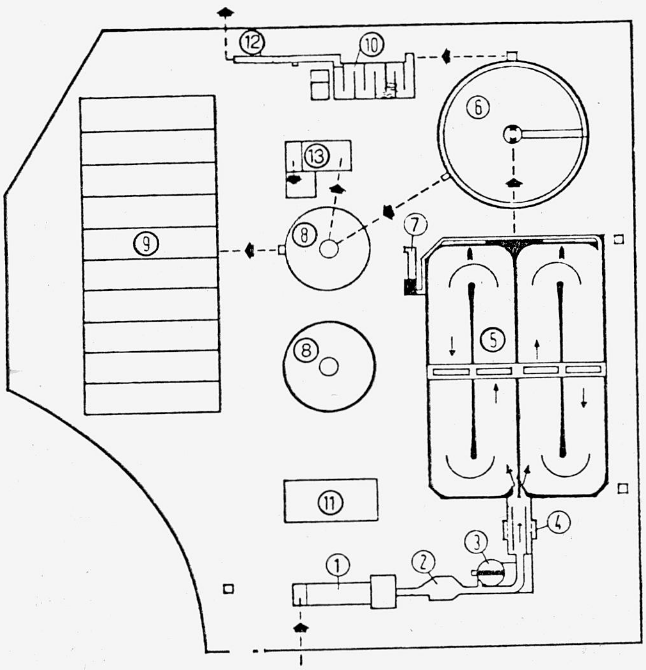

Fig. 1. Flow-sheet of Venice-San Giuliano sewage treatment plant

1 — pumping station, *2* — screening, 3 — grit removal, *4* — oil flotation, *5* — activated sludge basins, *6* — secondary sedimentation, *7* — recycling sludge pump, *8* — static sludge thickener, *9* — sludge drying beds, *10* — chlorination tanks, *11* — office-warehouse, *12* — flowmeter, *13* — mechanical dewatering

Rys. 1. Schemat technologiczny oczyszczalni ścieków San Giuliano w Wenecji

1 — stacja pomp, *2* — przesiewanie, *3* — usuwanie drobnych zanieczyszczeń mechanicznych, *4* — flotacja oleju, *5* — baseny osadu czynnego, *6* — sedymentacja wtórna, *7* — pompa zwracająca osad do obiegu, *8* — statyczny koncentrator osadu, *9* — poletka osadowe, *10* — zbiorniki chlorowania, *11* — magazyn, *12* — przepływomierz, *13* — mechaniczne odwadnianie

3. METHODS AND RESULTS

The experimental investigation is based on the analytical survey of the following parameters: COD, $N-NH_4$, $N-NO_3$, N_{org}, and N_{tot}. The analytical methods used in this examination are those given under *Standard Methods* [8].

In order to carry out the nitrification and denitrification processes simultaneously, some small changes in the plant had to be introduced (fig. 2) allowing to link in series the two oxidation basins. For this purpose the wall separating the two basins was equipped with a sliding gate operated by means of a handwheel. In order to avoid shortcircuit between the sewage inlet into the first basin and the stream flowing into the adjacent basin through the connecting sluice, the inlet channel was extended and led hanging over and

Table 1

Technical specifications of some operational units
and design parameters of the Venezia San Giuliano plant
Dane techniczne i parametry projektowe oczyszczalni San Giuliano
w Wenecji

Number of inhabitants who could be served	33,000
Number of inhabitants actually served	20,000
Type of sewage network	mixed
Average daily flow	400 m^3/h
Peak flow	595 m^3/h
Mixed flow allowed	2,160 m^3/h
Number of oxidation basins	2
Total net aeration volume	2,500 m^3
Length	40 m
Width	12 m
Depth	3 m
Number of rotors installed	4
Length of rotor	4.5 m
Net volume sedimentation tank	1,200 m^3
Net volume of thickener	825 m^3
Surface of drying beds	1,100 m^2
Volumetric load	0.8 kg $BOD/m^3 \times d$

beyond the sluice. Six electro-chemical probes were placed in the two basins in the positions shown in fig. 2 at a depth of approximately 1 m. The probes were coupled with an O_2-meter and two three-trace recorders for the continuous recording of the concentrations of dissolved oxygen.

Additionally three times a day (at 8 a.m., 12 noon, and 4 p.m.) a manual probing was carried out by means of one of the probes available. This survey was carried out in pre-arranged points (fig. 2) along the perimeter of the two basins at three pre-arranged depths (20 cm, 100 cm, 250 cm). Based on the information thus obtained, oxygen distribution maps were drawn. They were expected to allow the determination of the extension of the anoxic areas (DO < 0.5 mg/dm^3) and of the aerobic areas (DO > 0.5 mg/dm^3).

The wastewaters were sampled on the entrance (immediately before their entry into the oxidation tank and after the mechanical pre-treatment step) and on the exit (after the final sedimentation) at three fixed times, corresponding to the manual probing of the oxygen. The sampling was carried out with automatic samplers set for different sampling times.

This has allowed to evaluate the yield of BOD removal with regard to the hourly fluctuations of organic load, of the nitrogen load and, consequently, of the level of O_2 dissolved in the basins. The sludge samples were taken only once per day at a pre-set time (at noon).

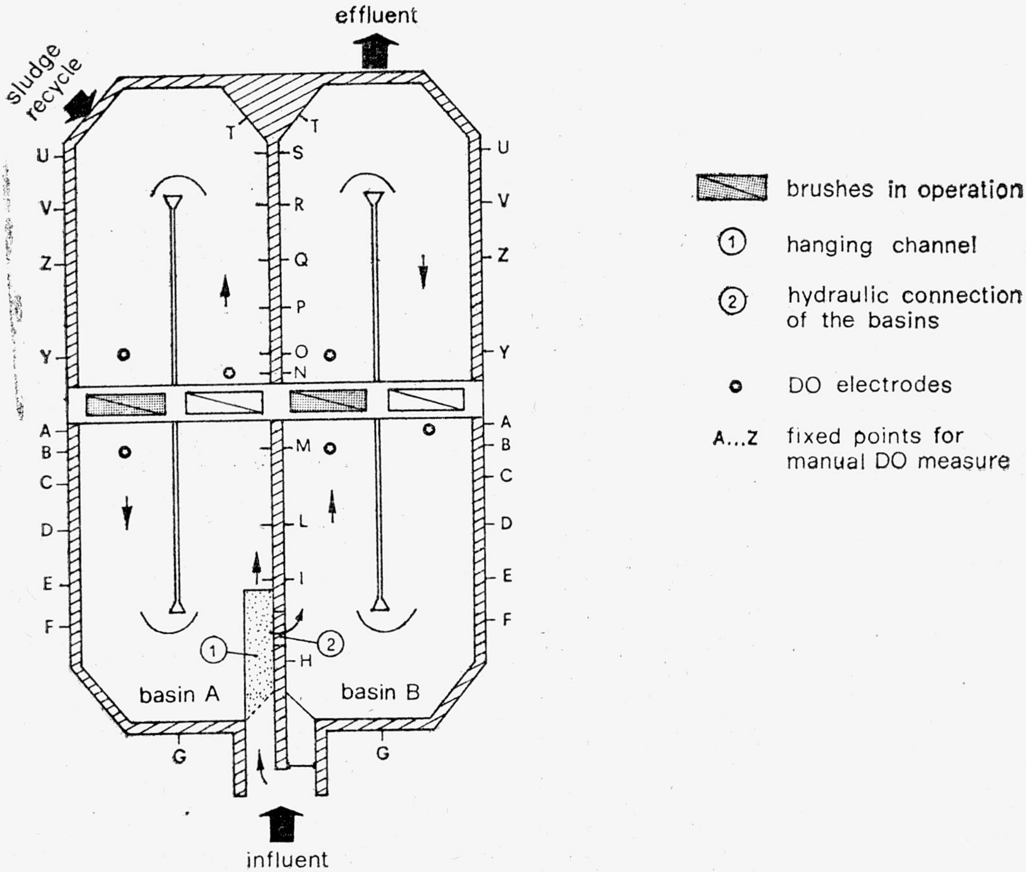

Fig. 2. Schematic representation of the modifications at Venice-San Giuliano sewage treatment plant carried out for the experimental runs on simultaneous nitrification–denitrification process

Rys. 2. Schemat oczyszczalni ścieków San Giuliano w Wenecji zmodyfikowanej do doświadczeń z jednoczesną nitryfikacją–denitryfikacją

The operating plan for the plant took into account the connection in series of the two basins A and B, according to the modifications described earlier (fig. 2). The raw sewage was fed into the basin A. The aerated mixture was discharged from basin B to be sent for final sedimentation. The sludge was recycled to tank A (by means of a screw pump) with a flow rate equal to that of the raw sewage (i.e. at a 100% recycling ratio). The rotors aeration capacity was controlled by adjusting their immersion depths by means of an adjustable weir in tank B. This resulted in a difference between hydraulic levels of these two basins and caused the immersion of the rotor in tank A to be 1–2 cm greater than that of the rotor in tank B.

Table 2

Mean results of the experiments on the simultaneous nitrification–denitrification in nine different research periods

Q — flow; I_A, I_B — rotors immersion in basins A, B; P_a — power consumed by rotors; SS_A — total suspended solids in the aeration tank; SS_R — total suspended solids in the recycled slugde; SV — volatile suspended solids in the aeration tank; I_M — Mohlmann index; C_f — sludge load, kg BOD/$SS_A \times$ day; T_A — temperature in the aeration tank; I — influent; U — effluent at different times, η — removal efficiency, %

Średnie wyniki doświadczeń nad jednoczesną nitryfikacją—denitryfikacją w dziewięciu różnych okresach badań

Q — przepływ; I_A, I_B — imersja wirników w zbiornikach A i B; P_a — moc zużyta przez wirniki; SS_A — całkowita zawiesina w komorze napowietrzania; SS_R — całkowita zawiesina w osadzie czynnym powtórnie włączonym do obiegu; SV — lotna zawiesina w komorze napowietrzania; I_M — wskaźnik Mohlmanna; C_f — obciążenie osadu czynnego, kg BZT/kg zawiesiny stałej $\times$ dzień; T_A — temperatura w komorze napowietrzania; I — dopływ; U — odpływ w różnym czasie, η — efektywność usuwania, %

Period and date		Q m/h	I_A cm	I_B	P_A Khw	SS_A g/dm³	SS_R g/dm³	SV/SS %	I_M	C_f kg BOD/kg $SS_A \times$ day	T_A °C	COD, mg/dm³								
												I_A	U_M	η	I_A	U_M	η	I_A	U_M	η
1	6.6/10.6	340	15	12	23.0	4.8	7.9	46	170	0.064	16	118	40	64.9	240	48	79.3	187	38	79.8
2	7.7/24.7	300	14	12	23.6	5.7	8.6	51	170	0.050	17	153	95	36.6	225	86	60.5	191	88	52.9
3	26.7/5.8	400	14	12	23.6	5.6	8.9	52	160	0.077	17	193	108	42.0	209	108	51.3	213	91	53.3
4	7.8/18.8	380	16	14	27.0	4.8	10.2	53	174	0.085	17.5	172	96	45.4	244	90	62.8	212	92	56.3
5	19.8/7.9	200	15	12	23.4	4.6	7.5	—	190	0.030	17.5	119	67	41.8	144	64	56.0	163	67	60.1
6	11.9/19.9	380	15	15	24.8	4.7	9.6	—	196	0.070	16.5	145	75	48.3	144	78	45.4	177	71	59.2
7	20.9/3.10	380	16	14	27.0	4.9	10.0	—	185	0.070	15.5	115	53	51.7	211	50	74.0	222	58	69.2
8	4.10/9.10	350	18	16	27.2	4.5	10.5	64	210	0.070	15	107	58	45.8	191	60	70.3	192	66	65.9
							effluent	basin	A			—	45	59.9	—	57	70.9	—	64	65.3
9	10.30/16.10	340	19	17	27.6	4.11	9.5	64	194	0.080	15	137	81	37.9	250	60	62.11	264	71	72.9
							effluent	basin	A			—	84	37.2	—	96	56.5		96	63.4

N_{tot}, mg/dm³									$N-NH_4$, mg/dm³						$N-NO_3^-$, mg/dm³					
I_8	U_8	η	I_{12}	U_{12}	η	I_{16}	U_{16}	η	I_8	U_8	I_{12}	U_{12}	I_{16}	U_{16}	I_R	U_R	I_{12}	U_{12}	I_{16}	U_{16}
12.2	5.0	53.1	19.8	16.2	66.9	16.0	6.4	60.1	10.4	4.4	19.0	2.5	14.7	4.8	—	1.2	—	3.4	—	1.3
7.9	6.6	15.3	19.2	5.1	74.4	16.1	6.7	56.4	6.9	0.4	18.1	0.1	14.3	0.2	—	5.9	—	4.8	—	6.3
7.9	5.4	27.2	18.2	5.8	68.8	13.8	6.0	55.1	6.5	0.8	16.6	0.4	12.4	0.8	0.1	3.7	—	5.0	—	4.8
78	3.7	55.2	19.1	4.1	78.1	12.8	5.5	57.1	6.5	0.7	17.4	0.3	11.4	1.6	0.2	2.7	—	3.4	0.1	3.5
8.1	9.4	8.8	16.7	10.0	38.6	13.9	9.9	52.1	7.0	0.2	15.6	0.2	13.2	0.5	—	9.2	—	9.8	—	9.5
11.6	8.6	27.8	27.6	6.8	75.0	21.0	9.1	56.2	10.1	8.0	25.2	5.9	19.0	8.0	—	0.1	—	0.6	—	0.6
10.2	7.9	26.5	22.4	6.8	68.5	25.6	10.1	56.2	11.5	7.5	21.6	6.3	20.6	9.5	0.1	0.3	—	0.3	—	0.3
7.5	4.5	45.8	21.2	3.7	81.3	15.4	5.7	52.2	6.7	2.4	19.7	1.5	14.2	4.4	0.3	1.9	—	2.1	—	2.1
	9.1	36.4		4.3	74.0		5.8	53.3		1.3		2.0		3.4		2.3		3.0		1.2
10.0	9.2	8.0	25.3	6.4	75.1	18.7	9.1	44.7	8.7	9.6	24.7	5.7	17.9	8.6	—	—	—	0.4	—	—
	5.8	37.9		8.0	65.3		11.2	37.6		5.0		7.5		10.9		0.3		0.2		—

Some initial attempts to create alternating anaerobic and aerobic areas in the two aeration basins, using all four rotors installed in the plant, did not give good results. In fact, with the different immersion depths of the rotors balanced conditions were never achieved and the dissolved oxygen remained homogeneously distributed, thus creating in both basins either globally anoxic conditions or globally aerobic conditions. This behaviour could be attributed to the low organic load of the raw sludge and to the short distance between the two rotors, which did not permit the establishment of areas in which the quantity of the oxygen used for the bacterial respiration exceeded the quantity of oxygen rendered possible by the aerators.

For these reasons the number of working rotors has been reduced to two, one for each basin. These two operating rotors were chosen as to achieve the mixing of wastewaters

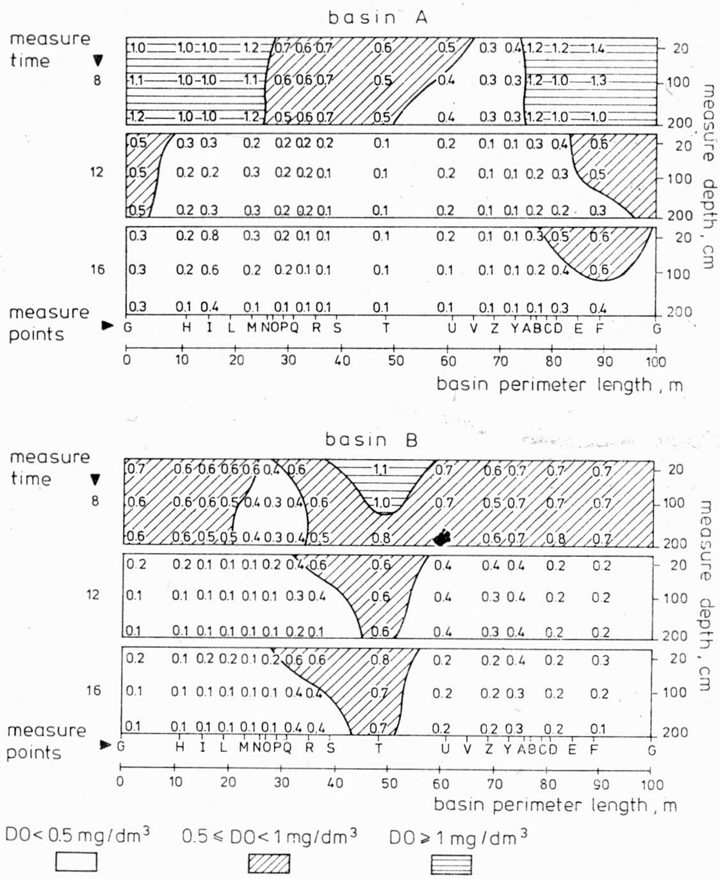

Fig. 3. Dissolved oxygen profiles in A and B basins (1st research period)

Rys. 3. Profile rozpuszczonego tlenu w basenach A i B (pierwszy okres badań) and the recycled sludge arriving into the first aeration basin A and to guarantee aerobic conditions for the final effluent from basin B (fig. 2). Despite the reduction of the power demand which has been achieved, a specific energy of approximately 9.2 W/m^3 was supplied at the point of minimum immersion of the rotors. This proved to be sufficient to hold the aerated mixture in suspension, thus avoiding in all points of the two basins an undesirable sedimentation.

On the basis of the new operation conditions a set of experiments were carried out in the period June–October 1979, during which the organic load and the rotor immersion were appropriately varied. It involved different sludge loads and different configuration of the profiles of the dissolved oxygen.

As a consequence of the different operation conditions nine research periods were distinguished. The average results achieved during the single pericds are shown in tab. 2.

The profiles of dissolved oxygen obtained in the basins A and B by means of daily sampling, in one of the research periods (1st period), are given in fig. 3 as an example.

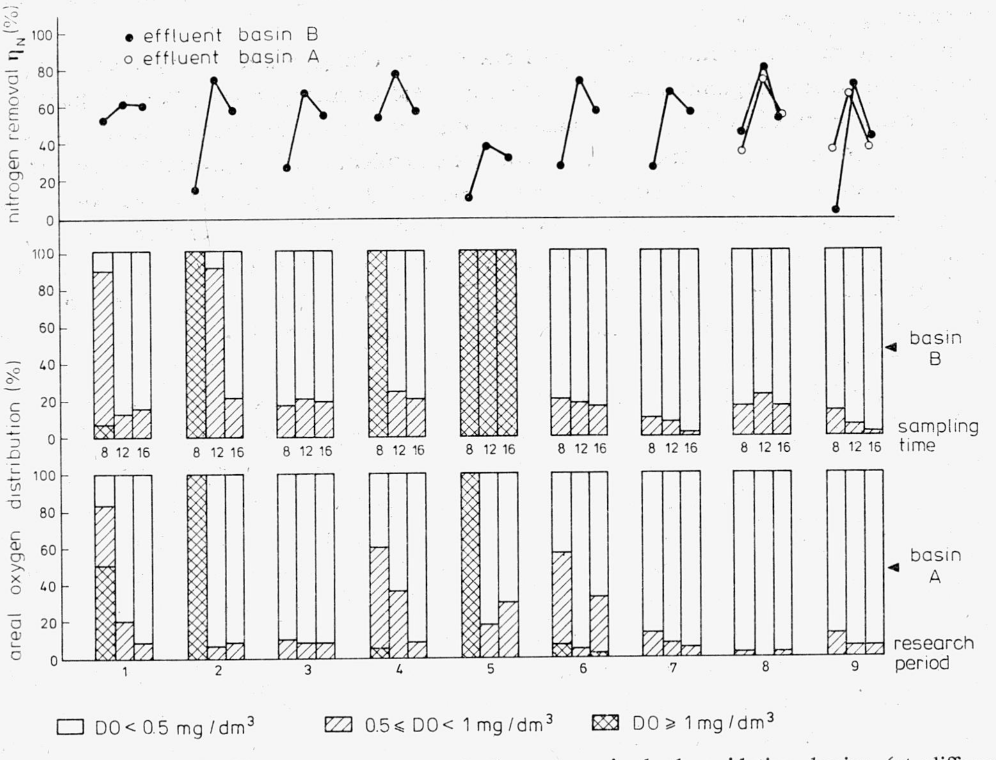

Fig. 4. Distribution of different oxygen concentration zones in both oxidation basins (at different research periods and different day times) and correspondent total nitrogen removal yield

Rys. 4. Strefowy rozkład różnych stężeń tlenu w obu basenach utleniania (w różnych okresach badań i w różnych porach dnia) i odpowiadająca mu wydajność usuwania całkowitego azotu

Similar profiles have been traced for the other research periods. On the basis of these profiles the percent distribution of the different areas at the different times of day has been found. This distribution is shown in fig. 4 together with the graphic representation of the course of the average yield of total nitrogen removal in the different periods and at the different times of the day.

4. DISCUSSION

In the course of the first research period after an initial period of adaptation, the optimum working conditions were achieved with a total nitrogen removal rate of 76.2%. The profiles of the dissolved oxygen (DO) which characterize this period (figs. 3 and 4) bring into evidence the different distribution of the anoxic areas and of the aerobic areas at the varying sampling times. At 8 a.m., there is a decisive prevalence of aerobic areas, whilst at the other two hours the anoxic areas prevail. This trend will often be observed in the subsequent research periods. The DO level in the two basins follows the stream of the entering organic load.

In fact, a minor respiratory activity of bacteria resulting in a low oxygen consumption corresponds to low organic loads. The average yield of nitrogen removal is higher at 12 noon, as the result of both the more balanced distribution of the anoxic and aerobic areas and the higher COD/N_{tot} ratio which favours denitrification. The average concentration of total nitrogen in the effluent at various times is 5.8 mg/m³. The nitrification appears particularly incomplete at 8 a.m. and at 4 p.m. ($\sim$4.5 mg $N-NH_4/dm^3$ in the effluent).

In the second period of research the load was decreased and the immersion of the rotors increased. The presence of extended aerobic areas, particularly in basin B, has allowed an almost complete nitrification with denitrification results being notably reduced (particularly at 8 a.m.).

The highest DO level, generally observed within basin B, is due to the fact that a large portion of the organic load (as can better be seen in the eight and nineth research periods) is eliminated in the first basin, thus the bacterial respiration and thereby the oxygen consumption are reduced. The highest yield of nitrogen removal stated at 12 noon (the average value equals to 74.4%) can be explained by the fact that at this time the process of nitrogen removal does not proceed according to the nitrification–denitrification pattern. In fact, in basin A the nitrates, formed in the presence of aerobic zones in the preceding hours, undergo denitrification.

Carbon necessary for the denitrification is supplied by the organic substance contained in the influent of raw wastewaters. A high percentage of nitrogen is thus already removed in basin A. Hence, in some days the yield of removal (ηN_{tot}) reaches 97.4%, with the NO_3 concentration in the effluent equal to 0.05 mg N/dm^3.

The possibility that a similar process takes place in basin B, between 12 noon and 4 p.m., shoud not be excluded. At 4 p.m., there may occure the denitrification of nitrates formed previously in the aerobic areas, evidenced in basin B at 12 noon.

In the third period of research the load has been increased and the immersion of the rotors kept unchanged. The DO distribution has been found homogenous at the three different times of sampling.

Despite a largely reduced extension in the aerated zones, the nitrification is complete. Nitrification and denitrification processes in the presence of DO levels near 0 mg/dm^3 take place simultaneously when the amount of oxygen supplied by the aerators is equal to that consumed by the bacterial respiration.

Low COD removal at a complete nitrification means that nitrification does not depend directly on the extent of the simultaneous oxidation of the organic substance. In this case, the highest average yield has also been found at 12 noon with $\eta N_{tot} = 68.8\%$ and a peak value of 80.5%. As in the earlier periods, the fluctuations in yield are not reflected in the effluent in which the average concentration of total nitrogen at various times is equal to 5.7 mg N/dm^3.

In the fourth period of research the increase of the immersion of the rotors and of the load of sludge has determined a balanced distribution of the anoxic and aerobic areas, which is manifested in satisfactory yields of nitrogen removal at various sampling times and, in particular at 12 noon ($\eta N_{tot} = 78.1\%$). In this case despite the prevailing anoxic areas, the nitrification is also complete.

In the fifth period of research due to the load reduction, aerobic conditions have been created in basin B and found there at each sampling time. These conditions have also been observed in basin A at 8 a.m. At 12 noon and at 4 p.m. the presence of anoxic areas could be recorded in basin A. In this case the oxygen supply largely exceeds its consumption, because of the weak bacterial respiration related to the low sludge load (C_f = 0.03 Kg · BOD/Kg · SS × day). The yield of average nitrogen removal at 12 noon is 38.6%, whilst its average concentration in the effluent at various times fluctuates around 10 mg/dm^3.

In the sixth period of research the DO profiles show that at various sampling times, the anoxic areas in both basins prevail and nitrogen in the effluent is almost totally in ammonia form (6–8 mg $N-NH_4$/dm^3). In this respect the situation differs from that seen in the precedent periods, when a complete nitrification is observed, even under anaerobic conditions. This can be explained by the increased load of nitrogen entering the plant as compared with that in the previous research periods.

The overall yield of nitrogen removal at 12 noon amounts, however, to 75%, with peak of 82%.

In the seventh period of research, in which the immersion of the rotors has been increased by 1 cm, the situation does not change significantly with respect to the previous period, so that the same considerations can be held valid.

In the eighth period of research the average capacity is slightly lower and the immersion of the rotors increased to 18 cm (basin A) and to 16 cm (basin B). The analytical survey has been extended and included the analysis of the mixed liquor discharged from the first tank (A) make so in order to evaluate the removal yield achieved in this first stage of the process. The analyses have been carried out in the same manner as for the samples of raw wastewaters and of the effluent.

The DO profiles show the prevalence of the anoxic zones, at all the sampling times. The yield of nitrogen removal is kept at a high rate ($\eta N_{tot} = 81.3\%$ at 12 noon) and average concentrations of nitrogen in the effluent fluctuate around 5 mg/dm^3 (tab. 2). The yield in effluent from the first basin, notwithstanding the fact that the nitrification is not complete, is high, often superior to those to be found in the final effluent. This latter phenomenon can be attributed to the release of nitrogen occurring in the second basin in correspondence with the prevailing anaerobic conditions existing there and due to the lack of organic substrate, which is removed mainly in the first basin.

Similar analysis of the results obtained in the ninth period of research, during which the immersion of the rotors has been increased by 1 cm with respect to the preceding period, shows that a large part of nitrogen and COD is already removed in the first basin. Thus, good removal results can be expected even with sludge loads greater than those usually applied to both basins.

4. CONCLUSIONS

From the experimental investigation carried on biological removal of nitrogen by the simultaneous nitrification–denitrification process, the following conclusions can be formulated:

1. The process, applied to a plant serving 33,00 inhabitants, depends basically on the organic load input and the concentrations of dissolved oxygen in the aeration tanks.

2. The balanced distribution of anoxic areas, in which the denitrification proceedes, and of aerobic zones, in which the nitrification occurs, has undoubtly influence on the process, albeit it is not decisive. Even under prevailing anoxic conditions in the two basins, good nitrification yield has been observed. The nitrifying bacteria therefore do not appear to be inhibited by low dissolved oxygen values, but their activity is closely related to the amount of oxygen supplied by the aerators. If this is sufficient, their metabolism does not suffer. At the same time it can be confirmed that the oxidation of the organic substance is not competitive with the activity of nitrifying bacteria. In fact, the nitrification is complete even in the presence of incomplete oxidation of the organic substance, as far as a sufficiently long period of contact between substrate and bacterial mass is guaranteed.

3. The daily fluctuations in the organic load entering the plant affect decisively the efficiency of the process. Particularly as regards the yield at 8 a.m., when low removal yields have always been obtained, specifically due to high dilution of the raw wastewaters entering.

4. Under the best working conditions, particularly in correspondence with the highest organic loads, removal yields of 80–90% have been reached.

5. The variations of N_{tot} in the effluent appear to be very limited, as also, in cases of a low yield, the concentration of N_{tot} generally oscillates between 5 and 6 mg/dm^3, once the most appropriate operation parameters have been fixed.

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BIOLOGICZNE USUWANIE AZOTU ZE ŚCIEKÓW O NISKIEJ ZAWARTOŚCI ZANIECZYSZCZEŃ ORGANICZNYCH PRZEZ JEDNOCZESNĄ NITRYFIKACJĘ I DENITRYFIKACJĘ

Przedstawiono wyniki badań nad biologicznym oczyszczaniem ścieków miejskich o niskiej zawartości zanieczyszczeń organicznych z równoczesnym usuwaniem związków azotowych. Badany proces wymagał odpowiedniego doboru warunków pracy rotorów, pozwalającego na uzyskanie stref aerobowych i anaerobowych, w których zachodziły odpowiednio procesy nitryfikacji i denitryfikacji ścieków. Całkowita zawartość azotu w ściekach oczyszczonych wynosiła 5–6 mg N/dm^3, podczas gdy ścieki surowe zawierały 10–28 mg N/dm^3, a ich ChZT mieściło się w granicach 100–200 mg O_2/dm^3.

STICKSTOFFELIMINIERUNG AUS SCHWACH BELASTETEN, ORGANISCHEN ABWÄSSERN DURCH GLEICHZEITIGE NITRIFIKATION UND DENITRIFIKATION

Dargestellt werden Versuche zur biologischen Reinigung von schwach belasteten, städtischen Abwässer beim gleichzeitigen Abbau von Stickstoffverbindungen. Dem Verfahren muß die Arbeitsweise der Belüftungskreisel derartig angepasst werden, daß aerobe und anaerobe Zonen mit der darin verlaufenden Nitrifikation und Denitrifikation nacheinander folgen.

Das zufliessende Abwasser wies einen CSB von 100–200 g O_2/m^3 und eine Stickstoffmenge von 10–28 g N/m^3 auf; im gereinigten Abwasser war die Stickstoffkonzentration nur noch 5–6 g N/m^3.

БИОЛОГИЧЕСКОЕ УДАЛЕНИЕ АЗОТА ИЗ СТОЧНЫХ ВОД С НИЗКИМ СОДЕРЖАНИЕМ ОРГАНИЧЕСКИХ ЗАГРЯЗНЕНИЙ ПОСРЕДСТВОМ ОДНОМЕРНОЙ НИТРИФИКАЦИИ И ДЕНИТРИФИКАЦИИ

Представлены результаты исследований по биологической очистке городских сточных вод с низким содержанием органических загрязнений с одновременным удалением азотных соединений. Исследуемый процесс требовал соответствующего подбора режима работы роторов, позволяющего получить аэробные и анаэробные зоны, в которых протекали соответственно процессы нитрификации и денитрификации сточных вод. Полное содержание азота в очищенных сточных водах составляло 5–6 мг Н/дм^3, тогда как сырые сточные воды содержали 10–28 мг Н/дм^3, а их ХПК содержалось в пределах 100–200 мг O_2/дм^3.