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NITROGEN REMOVAL FROM DOMESTIC WASTEWATER USING IMMOBILIZED PELLETS

V.Aravinthan, Dept of Urban Engineering, The University of Tokyo
C.Fujii, Y. Honda, Ministry of Construction
S.Takizawa, Engineering Research Institute, The University of Tokyo
K.Fujita, Dept. of Civil Engineering, Saitama University

1. Introduction

The Advanced wastewater treatment by the biological processes such as nitrification and denitrification has been successfully used for the treatment of domestic wastewater. The conventional wastewater treatment plants have to be modified so as to accomodate the nutrient removal as well. However, the modification of the original system demands additional space that may not be available at proximity of the existing plants. Therefore it is necessary to investigate the possibility of achieving effective treatment of wastewater with minimum space and detention time. It has been shown by the studies conducted in the past that nitrification could be accelerated by the addition of immobilized pellets in the bio-reactors. Hence denitrification is, at present, the rate limiting factor. The objective of the present study is to know whether the rate of denitrification can also be increased by the addition of immobilized pellets.

2. Materials and methods

The reactor set up is shown in the Figure 1. It has two runs namely A and B. Both anoxic and oxic reactors contain the immobilized pellets in Run A whereas the anoxic reactor in Run B does not contain the pellets and thus acting as the control for the above experiment. The poly-propylene pellets are of 3 mm in inner diameter, 4 mm in outer diameter, 5 mm in length and 1.001 in specific density. The HRT is maintained to be 4 Hrs in each Run. The contents of the synthetic wastewater are given in Table 1.

Table 1: Contents of synthetic wastewater

Contents	mg/l
skimmed milk	200 or 100
peptone	50
yeast extract	50
KCl	10
NaCl	5
$MgSO_4$	3
NH_4Cl	57
KH_2PO_4	14
$NaHCO_3$	200

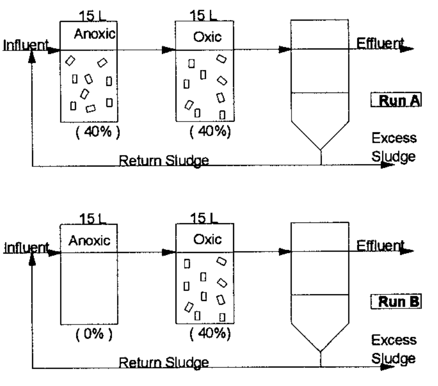

Fig. 1. Experimental Apparatus

During the course of continuous experiments, the conditions have been changed four times as shown in Table 2. All the parameters are analyzed in accordance with the procedures demonstrated in the Standard Methods (AWWA et al., 1992) twice a week. The attached population on the pellets is measured by first separating the biomass by sonification at 6 W/ml for 10 minutes and by weighing the dried biomass and the pellets at 103 °C.

Table 2: Change of conditions

Phase	No. of Days	Return Sludge	Nitrified Liquor Recyle	Temperature	Skimmed Milk (mg/L)
Phase 1	1 -127	100%	-	16~20 °C	200
Phase 2	128 - 202	100%	100%	18~22°C	200
Phase 3	203 - 257	100%	100%	15° C	200
Phase 4	258 - 415	100%	100%	15° C	100

3. Results and discussions

a) COD Removal Efficiency: COD removal efficiency remains to be above 90% in both Runs in all the Phases. No remarkable difference was found out between the two Runs.

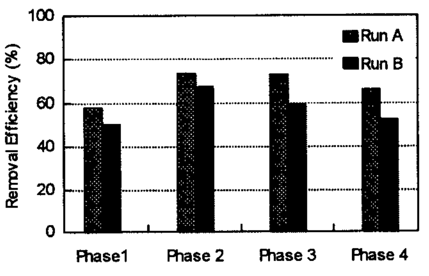

Fig. 2: Nitrogen Removal Efficiency

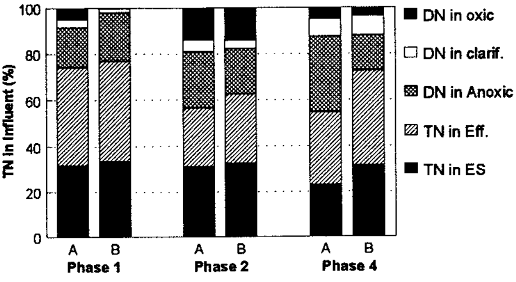

Fig. 3: Nitrogen Mass Balance

b) Nitrogen Removal Efficiency: Referring to Fig 2, the average nitrogen removal efficiency was 57.6% and 50.6% for Run A and Run B when the return sludge was 100 % (Phase 1) and increased to 73.8% and 67.3% when the total return was 200% (Phase 2). Average total nitrogen removal efficiency in Run A when the temperature was brought down to 15 °C in Phase 3, was 13.6% higher than that of Run B.

c) Nitrogen mass balance: Nitrogen mass balance is shown in Fig 3. During Phase 1, the denitrification in the mass balance was less that improved when the total return was 200%. Total nitrogen remained in the effluent was less and denitrification was higher in Phase 2. The overall denitrification was not affected by the reduced temperature and organic content (Phase 4) in Run A though it was not so in Run B. Also the contribution in denitrification by the anoxic reactor in Run A in Phase 4 was higher due to the increased biomass on the pellets. Total nitrogen content in the excess sludge remained about 30% throughout the experiment.

It is interesting to see that denitrification takes place not only in anoxic reactors but in the oxic reactors also. This is because when the biofilm thickness on the surface of the pellets is high enough, then there is a possibility of anoxic layer forming closer to the surface of the pellets as depletion of DO may occur in the biofilm irrespective of the DO present in the bulk liquid. Hence, deep into the biofilm, the oxidized nitrogen with enough carbon source and low DO will make the conditions conducive to possible denitrification.

The denitrification increase in the oxic tanks during Phase 2 could be due to the higher average temperature (about 22 °C) during this period. Reduced denitrification in Phase 4 when the organics were reduced to half the previous amount, could be due to very less amount of organics available to the bacteria deep in the biofilm than before and poor acclimatization in reduced temperature and organics.

Denitrification in the clarifiers is also of considerable amount which has to be discouraged to prevent sludge rising. The sludge in the clarifiers is in anoxic condition but the dissolved organics needed are minimal in the clarifiers which reveal that the sludge in the clarifiers looks for alternative sources of carbon such as the organics stored in their own cells for respiration purposes.

d) Denitrification rates from batch experiments: Denitrification rates as found out from the batch experiments are given in Table 3. It could be seen that the volumetric as well as the specific denitrification rates are higher for the pellets compared to the activated sludge due to high biomass concentration.

4. Conclusion:

Experiments conducted so far indicate that the anoxic reactor with the pellets shows stable and higher nitrogen removal over the one without it whenever there is a change in a condition such as temperature drop and low organic loading for a detention time of 2 hrs. This can be attributed to the higher amount of attached biomass in the anoxic tank in Run A resulting in higher percentage of denitrification. Thus having pellets in both anoxic and oxic reactors will ensure higher nitrogen removal in the treatment plants. Batch experiments conducted also suggest that the volumetric denitrification rate is rather higher for the biomass attached on the pellets than the activated sludge.

Table 3: Denitrification rate

Denitrification rate	Volumetric	Specific
Unit	(mgN/L/h)	(mgN/gMLSS/h)
Pellets	6.36	5.44
Activated sludge-A	3.51	4.92
Activated sludge-B	2.07	5.03