B−27 Evaluation of simultaneous nitrogen and phosphorus removal performance of the anaerobic/anoxic cycle reactor applying for effluent of sewage treated UASB+DHS system

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1. INTRODUCTION

A combination of up-flow anaerobic sludge blanket (UASB) reactor and down-flow sponge (DHS) reactor as post treatment was developed as an appropriate sewage treatment technology (Machdar *et al.*, 2000;Tandukar et al., 2005, 2006;Takahashi *et al.*, 2011). This combination of UASB+DHS system effectively treated the sewage of its organic pollutants and the ammonium nitrogen. However the nitrate nitrogen and phosphorus nutrients could not be removed.

The anaerobic/anoxic sequencing batch reactor (A_2SBR) process is known to remove phosphorous besides removing organic carbon and nitrogen. In the A_2SBR process, nitrogen and phosphorus were degraded by denitrifying phosphate-accumulating organisms (DPAOs) (Kuba *et al.*, 1994, 1996; Tsuneda *et al.*, 2005). Also, A_2SBR provides the advantages of low requirements of carbon source, low power demand, low space requirements and effective nutrient removals.

The aim of the present study was to investigate the application of the integrated system consisting of UASB+DHS system, followed by A_2SBR reactor as advanced treatment for domestic sewage treatment.

2. MATERIALS AND METHODS

2.1 Experimental setup of A_2SBR

Fig. 1 shows the schematic diagram of the experimental setup of an A_2SBR, which was installed at the Nagaoka city sewage treatment center, Japan. The A_2SBR unit was set up in a poly-tank of 528 mm ϕ x 855mm H. The unit was run in cyclic modes of anaerobic and anoxic states. A peristaltic pump was used to feed the effluent from the UASB+DHS during the operation. The UASB+DHS system was used as pre-treatment for the reactor by Ono et al. (2011). Fig. 2 shows the reaction time of each phase that was controlled by a timer automatically. A mechanical mixer was installed inside the tank and operated using a timer. The unit was operated at HRT of 12 hours. Sodium acetate was used as an external carbon source for efficient denitrification and phosphorus removal by DPAOs. As to seeding sludge, the A_2SBR was inoculated with activated sludge from a municipal sewage treatment plant.

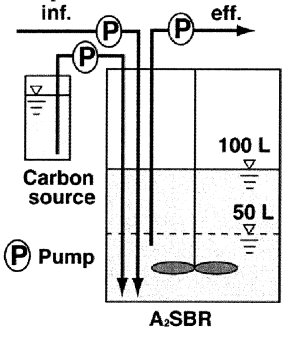

Fig. 1:The schematic diagram of the experimental setup of A_2SBR.

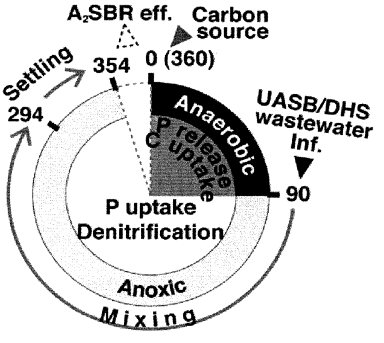

Fig. 2: The operational reaction time of each stage of A_2SBR.

2.2 Sampling and analytical methods

Grab samples of the influent and effluent of the UASB ,DHS and A_2SBR were collected and immediately analysed for pH, ORP, temperature and dissolved oxygen (DO) *in situ*. The pH was measured using a pH meter (D-14 Horiba) and DO was measured using a DO meter

(DO-24P Horiba). The total COD, soluble COD, Nitrogen and Phosphates were analysed using HACH water quality analyser (DR-2800, HACH)

2.3 FISH with Cy3 labeled oligonucleotide probes for cell count

FISH was tested to detect bacteria, PAOs (phosphorus accumulating organisms), and GAOs (glycogen accumulating organisms) that is competitive cell of PAOs. Oligonucleotide probes EUB338-mix (EUB338-1, 2, 3) were used for almost all bacteria, PAO-mix (PAO462, 651, 846) for PAOs and DPAOs, and GAO-mix (GAO431, 989) and TFO-mix (TFO_DF431, 618) for GAOs. For each probe and sample, at least 700 DAPI-stained objects were counted. Quantitative estimation was indicated by cell counting of PAOs and bacteria.

3. RESULTS AND DISCUSSION

3.1 Nitrogen and Phosphorus removal

Fig.3 (A) shows the time course of NO_3^- as N concentration and (B) PO_4^{3-} - P concentration. NO_3^- as N concentrations in influent were 9.8 to 25.5 mg/L as N. NO_3^- -N concentration in effluent became less than 5 mg/L as N throughout the experimental period and the removal rate was 89 ± 14%.

PO_4^{3-} as P concentrations in effluent during the period of uncontrolled pH was unstable. However, we were able to achieve the following: 1 mg/L as P by adjusting the pH

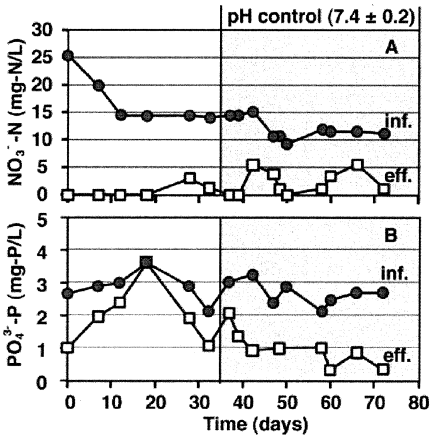

Fig.3: Time course of the system performance (A) NO_3^--N concentration, (B) PO_4^{3-}-P concentration.

(7.4 ± 0.2). In this study, A_2SBR was added with acetic acid as an organic carbon source as DPAOs have high substrate affinity for it. Simultaneous nitrogen and phosphorus removal was achieved by maintaining the COD/P ratio of 20.

3.2 The presence of PAOs and DPAOs

PAO MIX fluorescence was observed throughout the operation period, but the GAO MIX and TFO MIX fluorescence was not observed. The presence of PAOs increased after starting pH control and the percentage of PAOs present on day 66 reached 15%. Also, phosphorus uptake activity was analyzed by testing the percentage of phosphorus accumulating bacteria and DPAOs in the sludge for the first 47 days, during which the percentage of DPAOs was 91%, which is higher than the reported values of 54 % in the Anaerobic/Anoxic nitrification and 64% in the Anaerobic/Aerobic/Anoxic /Aerobic reactors. The sludge conversion ratio was 0.24 g-MLSS/g-COD removal. This value is almost equal to the theoretical value of DPAOs (0.26 g-MLSS/g-COD removal), a value of about 33% of the activated sludge.

Phosphorus content in the sludge reached 0.12 g-P/g-MLSS on day 42 at the end of anoxic conditions after the pH was adjusted. This phosphorus content value is higher compared to 0.03-0.04 for the existing biological phosphorus removal systems and is considered to be a valuable resource.

4. CONCLUSIONS

1) NO_3^--N concentration in effluent remained less than 5 mg/L as N throughout the experimental period.

2) Phosphorus removal as low as 1 mg/L as P was achieved after adjusting the pH (7.4 ± 0.2).

3) The community of PAOs increased after the start of pH control and the percentage of PAOs present on day 66 reached 15% with DPAOs/PAOs ratio of 91%.

5. REFERENCE

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