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Effect of Hydraulic Retention Time and Recycle Ratio on Anoxic/Oxic Bioreactor and Artificial Wetland Performance for Domestic Wastewater Treatment

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ABSTRACT

In this study, the effect of Hydraulic retention time (HRT) and recycle ratios on anoxic/oxic Bioreactor and Artificial wetland Performance for domestic wastewater treatment were experimented. Chemical Oxygen demand (COD), Ammonium nitrogen (NH4+-N), Nitrate nitrogen (NO3—N) and Total phosphorus (TP) removal were examined. The temperature was maintained at 20 to 24 and pH ranges was 7.6 – 8.1. The result revealed average COD removal efficiencies of 47, 68, 74, 83 and 85% at HRT of 1.5, 4, 2, 3 and 5hrs, and recycle ratios of 3, 2, and 1. Average removal of NH4+-N was 78, 85, 88 and 89 % at HRT of 5, 3, 4 and 1.5hrs and recycle ratios of 1, 2, and 3. Average removal of NO_3^--N was 92, 94, 95 and 97% at HRT of 2, 1.5, 3, 5 and 4hrs and recycle ratios of 3, 1 and 2. The average removal of TP was 78, 85, 88 and 89% at HRT of 5, 3, 2 and 1hr with recycle ratios of 1, 2, and 3 respectively. The system removed up to 74.1, 85%, 94.4% and 85% of the COD, NH_4^+-N, NO_3^--N and TP at different HRT, recycle ratios and with proper pH control using external source of alkalinity. The optimum recycle ratio was found to be 3. The result revealed high removal performance at increasing HRT and recycle ratios.

Key words: Hydraulic retention time (HRT), Recycle ratios; Anoxic/Oxic bioreactor; Artifical wetland; Alkalinity.

INTRODUCTION

China is experiencing rapid urban growth. Mounting population, industrialization, urbanization and changing life style are contributing to the random generation and disposal of wastewater which in turns pollute the water environment. Nowadays, domestic wastewater has been widely studied by many researchers using different treatment processes, either by application of high-rate aerobic systems [1, 2, 3], or by application of low-rate systems [3] and vertical flow constructed wetlands [4]. Constructed wetlands are considered as an appropriate technology for treating domestic sewage in the rural areas of China with climatic, population, and socioeconomic considerations [5]. To meet the standard effluent quality discharge of China, integrated A/O system and constructed wetlands was used and considered to be the best option for domestic wastewater treatment.

MATERIALS AND METHODS

Experimental set-up

The experimental system was made up of an influent tank, pumps (model BT100), the integrated A/O system and artificial wetlands, an air compressor for aeration and automatic aeration mixers to provide aeration in the oxic zones. The anoxic reactor has a total effective volume of 60 L and the oxic reactor has three segments with a total capacity of 27L. The reactor was connected in series with an internal diameter of 0.2m and a height of 2m for the anoxic columns. The oxic column has width size of 30cm and effective depth of 10cm, 20 and 30cm for first, second and third oxic segment. The height difference between each adjacent unit of Oxic is 0.5m. The domestic sewage drops to some porous baffles after it was pumped to a certain height. Both of the reactor's columns (A/O) were filled with a non-woven fabric filter materials. The artificial wetland has a plot area of 1.2m^2 and bottom slope of 0.003%. Each chamber was composed of three different layers of matrix particles of different sizes: the 200mm layer of coarse gravel (20 to 40mm in diameter) and the 250 mm layer of grit gravel in the bottom, in the upper is a 100mm layer of fine sand (0.5-1.2 mm in diameter). The artificial wetland was planted with Chinese celery (*Oenanthe javanica).* Temperature was maintained in the range of 20 to 26.

Wastewater for the experiment and Analytical Procedures

Raw wastewater from a campus main manhole was pumped into a storing tank for sedimentation and then fed into the reactor. The A/O reactor was inoculated with sludge obtained from Wuxi municipal sewage treatment plant. The raw domestic wastewater composition is shown in Table 1. The influent and effluent samples were collected in separate bottles after every two days and stored in refrigerator at 4°C before experimental tests. The internal recycle ratio, R, can be defined as the ratio of returned flow rate (Qr) to that of the main influent flow rate (Q0).

All the analyses were carried out in accordance to[6]. The influent and the effluent COD, NH4+-N, NO3--N and TP were measured according to[7].

RESULTS AND DISCUSSION

Organic material removal (COD)

The average concentrations of COD in the influent and effluent during the experimental operations were 91.1mg/L and 17.4mg/L respectively. It can be noted that, COD removal efficiency increases with increase in HRT (fig. 1 (a)). The overall removal efficiency of COD was 70.4%. This result obtained is quite similar to the study conducted by [8, 9]. In this study, the average removal of COD was 42, 68, 74, 83, and 85% with effluent concentration of 34, 17.5, 11.7, 7.7 and 15.9mg/l under HRT of 1.5, 4, 2, 3 and 5hrs, with recycle ratios of 3, 2 and 1 respectively.

NH_4^+-N and NO_3^--N removal

The overall removal of NH_4^+-N by the reactor was 85% quite similar to that obtained by [8]. The average concentrations of NH_4^+-N in the influent, anoxic oxic and artificial wetland during the experimental operations were 11, 2.4, 1.1 and 1.5mg/L respectively. The average removal of NH_4^+-N were 78, 85, 85, 88 and 89 % with effluent concentration of 1.9, 1.2, 1.3, 2.1 and 1.2mg/l operated with HRT of 5, 3, 2, 4 and 1hr respectively (fig. 1(b)). According to literatures and a study by [10], the optimum pH condition for nitrifying bacteria is 7.5 to 8.6. For this study, the value of pH was maintained between the ranges of 7.6 to 8.1 indicating satisfactory condition of the reactor. In order for simultaneous nitrification and denitrification to take place in the anoxic reactor, the reactor was intermittently aerated. The average DO concentration in the reactor was in range of 2.2 to 3.1 mg O_2/l, respectively.

During the operation, there was high concentration NO_3^--N in the effluent of the nitrification reactor (oxic). The overall removal of NO_3^--N by the system was 94%. The average removal of NO_3^--N was 92, 94, 94 and 97% with effluent concentration of 0.3, 0.2and 0.5mg/l operated with HRT of 2, 3, 5and 4hrs and recycle ratios of 2, 3, and 1 respectively (fig. 1 (c)). Increase

Table 1: Composition of the studied area domestic raw wastewater

Parameter	Min	Max	Average
COD (mg/L)	56.2	148.1	92.5
NH4+-N (mg/L)	7.13	24.99	11.04
NO3--N (mg/L)	3.4	6.2	4.8
TP	2.9	5.4	3.8
pH	7.7	8.2	7.9

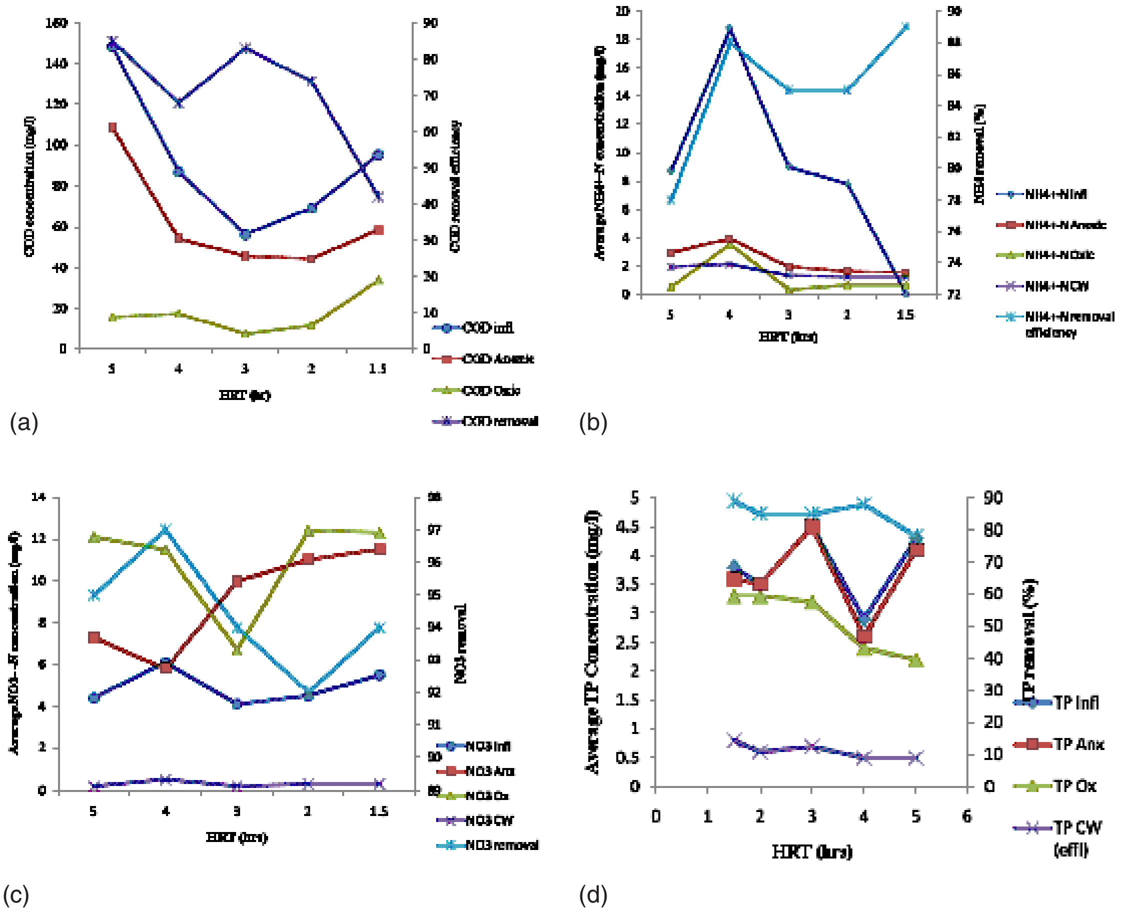

Fig. 1: Effect of HRT on removal efficiency of (a) average COD, (b) average NH4+-N, (c) average NO_3—N and (d) average TP concentration in the influent, anoxic, oxic reactors and artificial wetland

in recycle ratio (R) enhances the denitrification efficiency of A/O but according to [11], high increase of recycle ratio also inhibits denitrification.

Total phosphorus removal

The removal of TP was quite stable despite the concentration of TP in the influent was ranging between 2.9mg/l to 4.5mg/l. The effluent TP was mostly below 0.5 mg/. Most of the TP removal was accomplished in artificial wetland. The overall removal efficiency was 83%. The average removal of TP was 78, 85, 88 and 89% with influent and effluent concentration of 4.3, 3.5, 4.5, 2.9, 3.8mg/l and 0.5, 0.6, 0.7, 0.5 and 0.8mg/l operated with HRT of 5, 3, 2, and 1hr with recycle ratios of 3, 2 and 1 respectively (fig. 1(d)). Although temperature fluctuates and reed in the artificial wetland withered steadily during the winter season, TP removal wasn't affected.

CONCLUSIONS

This study used A/O and constructed wetland for treatment of campus domestic wastewater at different operating condition. According to the result obtained during the whole experimental operation, the A/O reactor and constructed wetland emerge to be well suited to the treatment of this kind of low strength campus domestic wastewater. Since heterotroph uses organic substrates as a source of carbon, heterotrophic denitrification is responsible for COD degradation. In the constructed wetland, most of the TP removal was accomplished by medium interception, microbial transformation and plant adsorption. The result obtained revealed that, the A/O reactor and constructed wetland is suitable and efficient in organic matter and nutrient removal

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