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Biological Behavior of Anammox Process for Municipal Wastewater Treatment: Effect of Ammonia Removal and Other Parameters

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ABSTRACT
Historically, nitrogen compound due to major environmental and public health problems have been considered. Anaerobic ammonium oxidation processes were proposed by many advantages such as; novelty, promising method and cost-effective. In this work, we used of anommax process for a wastewater with high C:N ratios and the main parameter likes pH; temperature, NO_2/NH_4 ratio and behavior of COD, ammonium and nitrite during operation time of 55 days were evaluated. High efficiency in nitrite and ammonium removal is observed at pH values between 7.5 to 8 and operation times between 9 to 23 days. Furthermorethe variation of the nitrite/ammonium ratio done dependence to pH, and a higher ratio was associated with higher pH values. And lower values of NO_2/NH_4 ratio have occurred with decrease of pH at third phase of anommax process. The average elimination efficiency of COD was occurred about 89.22%, but the removal efficiency of COD in anommax reactor was obtained about 49.5%. Furthermorethe removal efficiency of ammonium and nitrite were provided about 50% for each.

Keywords: Anammox process, ammonium, partial nitrification and C:N ratios

1. INTRODUCTION
In the treatment process, the nitrogen compound as a major problem has been concerned, historically. Biological nitrification–denitrification is the most commonly used process for nitrogen removal from wastewater (Eq. 1)[1], And this process can be used for municipal wastewater, especially[2]. Both Chemical treatment (magnesium/ammonium/phosphate (MAP) precipitation) and air stripping is feasible to elimination of ammonium, but these are expensive than classical nitrification and denitrification[3,4]. Also using the ion exchange to ammonium elimination has been investigated [5,6]. One process of other treatment ways is the anaerobic ammonium oxidation (Anammox) and bacteria oxidize ammonium under anoxic conditions with nitrite as the electron acceptor as (Eq. 2)[7-9]:

$$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^- \rightarrow NO_2^- \rightarrow N_2 \quad (1)$$

$$NH_4^+ + 1.32NO_2^- + 0.066HCO_3^- + 0.13H^+ \rightarrow 0.066CH_2O_{0.5}N_{0.15} + 1.02N_2 + 0.26NO_3^- + 2.03H_2O \quad (2)$$

In compared to conventional process, it is a novel, promising, low-cost alternative[10-12]. The Anommax process is suitable for wastewater with low C:N ratios. At C:N ratios above 1, the Anommax bacteria are no longer able to compete with heterotrophic denitrifying bacteria [13]. According to Anommax condition, that is appropriate to industrial wastewater. In comparison to conventional nitrification and denitrification process, Anommax needed to lower than 50% oxygen demand and consumes 100% less biodegradable organic carbon[14]. Also in this process, there is saving of cost by no adding organic carbon in combined with partial nitrification [12]. The main parameters in Anommaxare pH and temperature and biological community are very sensitive to aeration of these agents. In this work, we used of Anommax for municipal wastewater treatment and our novelty in this study is the application of Anommaxfor higher C:N ratios rather than conventional Anommax usage, and this study don't report by any authors.

2. MATERIAL AND METHODS
The synthetic wastewater was prepared in laboratory scale in compared to desirable characterizes. All reagents were provided of analytical grade from Merck and Sigma Company. These regents on to three types as micro elements, macro elements and nutrients (for start-up step) are provided in Table-1.

2.1 *Analytical techniques*
Referring to standard methods for the examination of water and wastewater, all experiments such as: COD, Nitrate and nitrite, Ammonium were performed[15].

2.2 *Start-up*
First, to provide the microbial cultures of Anommax process the start-up stage was used. In this stage, a bioreactor in volume of 30 liter as Fig.1 was made and was filled with fluid medium with surface area of 800 m^3/m^2 (Fig.2). Added

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nutrients for supportive of Anommax bacteria growth listed in Table.1. This reactor was fed on top and recycled the contents to achieve desirable contact time during six months. Start-up reactor was operated in anaerobic conditions and batch flow mode. The start-up reactor was fabricated at 170 cm height and 15 cm diameter.

Table-1: The composition of the mineral medium

Micro elements	**mg/kg $_{COD}$**	**Macro elements**	**g/L**	**Nutrients $_{start-up}$**	**g/L**
$Al_2(SO_4)_3,2H_2O$	1.9	NH_4Cl	1.383	NH_4Cl	0.3
$CaCl_2,6H_2O$	693.8	$C_6H_{12}O_6$	0.156	$NaHCO_3$	0.07
$CoCl_2$	4.02	KH_2PO_4	0.07	$NaNO_2$	0.15
$CuCl_2$	0.6	$NaHCO_3$	2.16		
$FeCl_3,6H_2O$	482.1				
$MgSO_4,7H_2O$	2563.5				
$MnSO_4, H_2O$	3.1				
$(NH_4)_6Mo_7O_{24},H_2O$	0.2				
$NiCl_2,6H_2O$	2				
$ZnCl_2$	6.3				
EDTA	0.006				

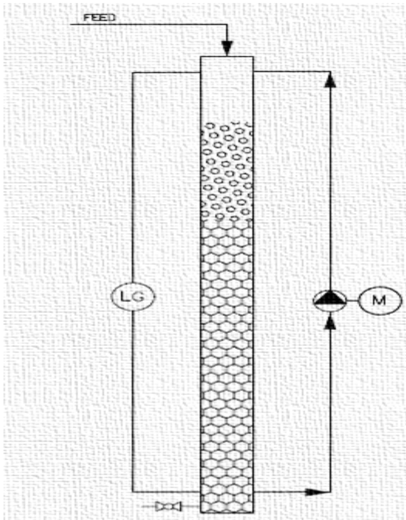

Fig-1: Start-up Reactor configuration.

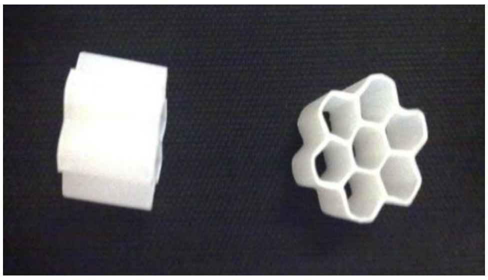

Fig-2: The construction of fluid medium.

2.3 *Reactor experiments*

Fig.3 (a) is shown the overall flow-sheet that consists of Sharon (partial Aeration) and Anommax process with a sedimentation reactor. In order to creation, the partial nitrification was used the Sharon reactor and reduction the portion of organic carbon. In sedimentation tank is occurred adjacent the C:N ratios and was equipped with pumps to aeration. Anommax reactor was fabricated in Plexiglas structure with 100 cm height and 25 cm diameter and filled with fluid medium and harvested biomass cultures from start-up stage that was used in start-up stage. The Anommax process was prepared in useful volume of 10 Liter and was conducted on continuous and up flow forms. Anommax was operated on three conditions of organic load and HRT 24 hours and 3-5 day of SRT were considered for 55 days. Fig.3 (b) indicates the prepared bacterial cultures in start-up stage and provided during 55 days. And the Rod colors of bacterial culture are considered as desirable growth.

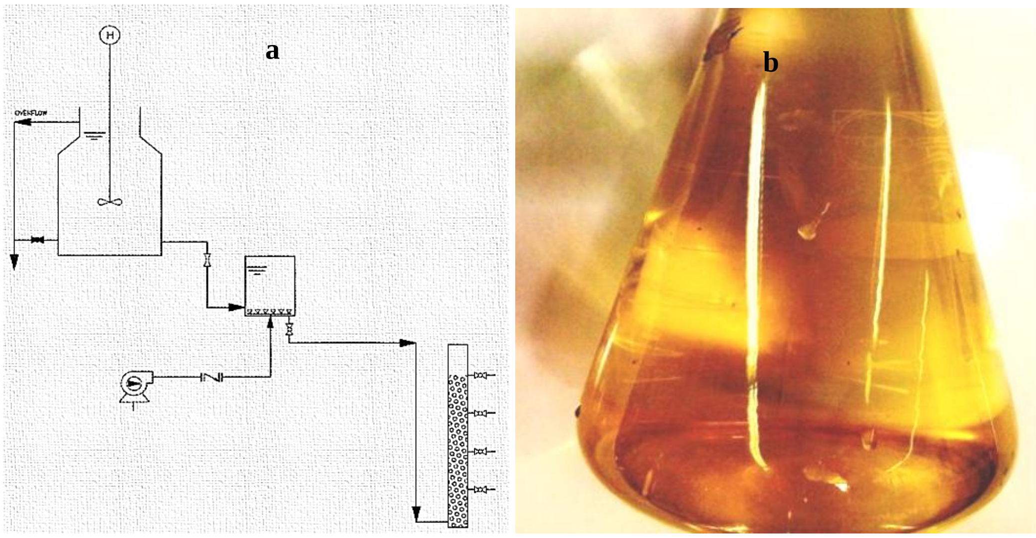

Fig-3: Schematic Sharon, sedimentation and Anommax Reactors (a) Anommax bacteria (b).

3. RESULTS AND DISCUSSION

3.1 *Nitrite, Ammonium*

As seen the overall variations, the important parameter of Anommax reactor is shown Fig.4. First step, the ammonium influences adjacent in three concentrations of 40, 60 and 80 mg/L that takes placea low, medium and high rate, respectively. Although three stages in all of the experiments were considered. Due to aerobic activity of heterotrophic cultures have been decreased the most of the ammonium concentrations. According to Fig.5 diagram can be found that the developed nitrite is dependence with initial NH_4 load. This can be occurred by primary accordance of bacterial cultures and setupping system, and return can be found higher compatibility at medium stage. Generally, can be expressed the better contents of residual ammonium in each reactor are occurred in higher amounts of ammonium loads. Also the residual of ammonium and nitrate in Anommax reactor are at lower amounts of itself. Therefore, this reduction can be approved the successful performance of the anaerobic biological treating on Anommax.

Fig. 6 illustrates the efficiency of ammonium and nitrite removal with variation of pH at during the operation time. That resulting from three stages performance of Anommax reactor and can consider a removal percentage of 50% for the entering nitrite to Anommax tank. Maximum removal rate of ammonium was acquired 50% during the third phase of the ammonium loading. The relatively regular trend of converting the nitrate and ammonium can be due to stable conditions in the Anommax process. In addition, the variation of pH shows on all the periods of operation and that is illustrated small fluctuations in range of pH 6.3-8. According to plots can be found the best conditions of pH for removal of nitrite and ammonium occurred at pH 7.5-8 and operation time of 11 to 21 days. Chamchoi and Nitisoravut (2007) have been reported the higher ammonium removal efficiency obtained in range of pH of 7.3–8.3 during a stationary phase [16].

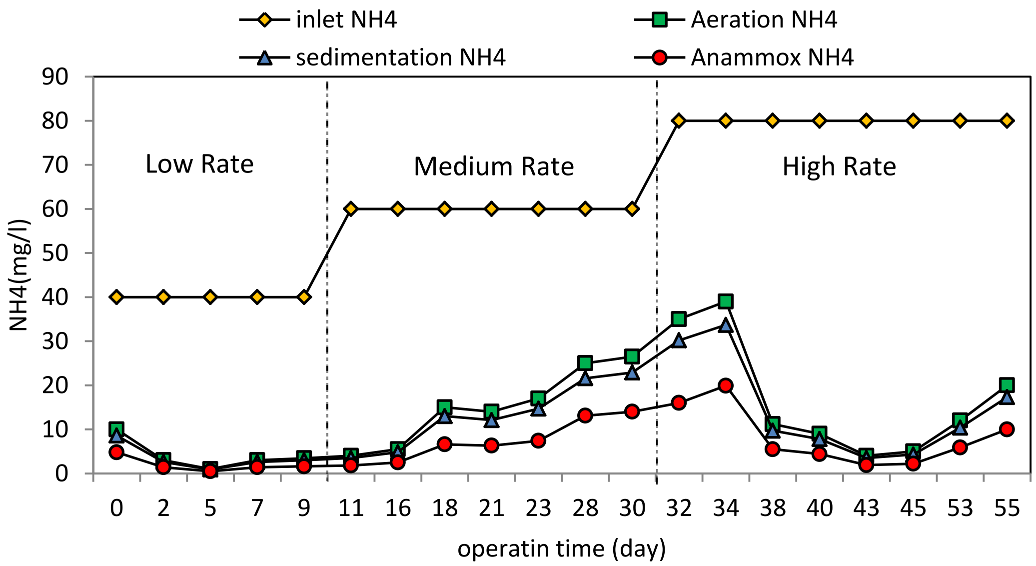

Fig-4: The trend of nitrogen compounds during aeration, sedimentation and anommax process.

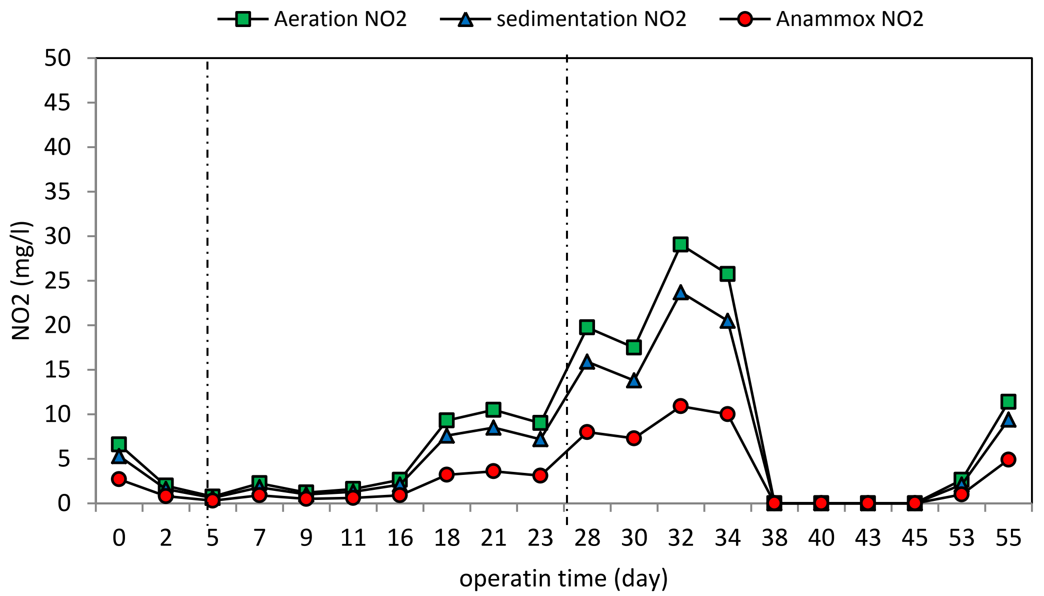

Fig-5: The trend of nitrogen compounds during aeration, sedimentation and Anommax process.

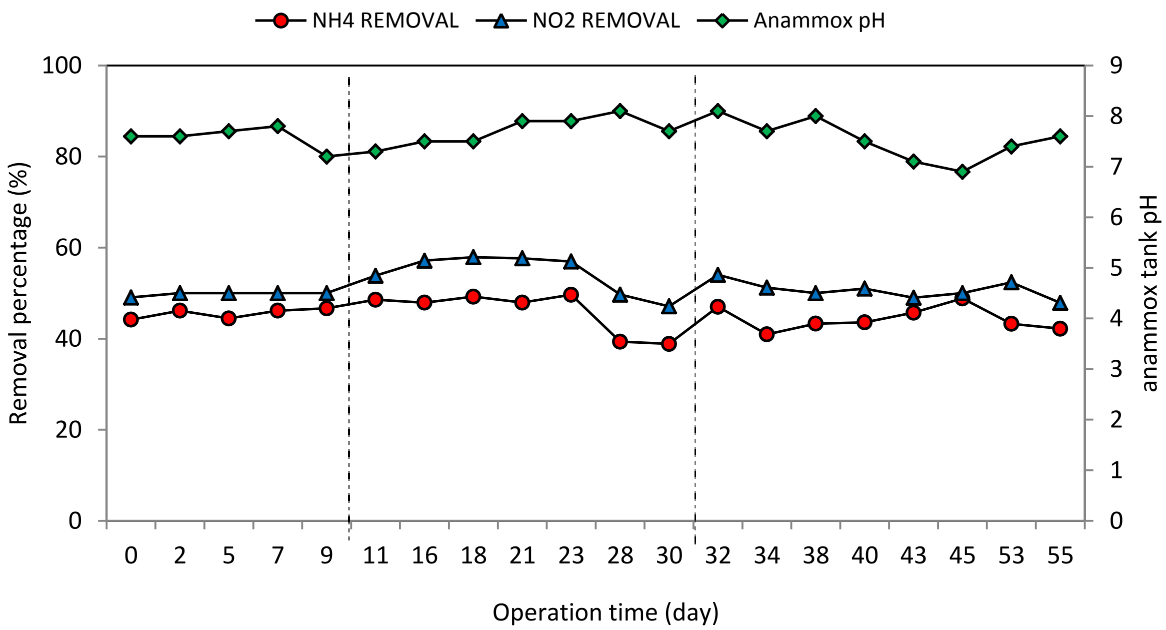

Fig-6: The trend of pH, nitrite and ammonium removal during Anommax process.

3.2 *Effect of process on COD*

The removal trend of COD values in three stages for aeration and anommax process are shown in Fig-7. According to reports of Molinuevo (2009)[9], the growths of anommax bacteria are influenced heterotrophic denitrifiers and return these bacteria are dominated at higher COD. Hence, the main port of COD Much must be removed in the aeration process, and this act was performed in Sharon'sprocess (partial aeration reactor). At the similar trend can be seen the removal rate of COD at aeration tank is close to the amount of removed values in the anommax reactor. The average efficiency of the elimination of COD has occurred with theregular trend about 89.22%, but the removal rate of COD in anommax reactor has been made irregularly, and average rate on efficiency was obtained about 49.5%.

3.3 *Temperature variation and NO_2/NH_4 ratio*

In anommax process, the controlling parameters are temperature and pH, and culture's bacteria are very sensitive to these parameters. Fig. 8 displays the variation of temperature versus operation time in aeration, sedimentation and anommax reactors. Desirable amount of this factor for Nitrifying bacteria is about 35 ^{o}C and lower than it, in the effluent can make to increase the both of nitrite concentration and COD removal rate and ammonia concentration decreased. However, in higher temperature of 35 ^{o}C, nitrite and COD removal rate decreased, and the ammonium content increased[17]. At present work, natural temperature was considered. More fluctuation of temperature is seen in aeration phase and this relatively regular in sedimentation and anommax reactors. Generally can be expressed amounts of temperature in anommax are more than sedimentation tank and this higher amount occurred due to biological activities of anommax reactor. Higher temperature is observed at operating time of 9 to 23 days and in this time was found maximum efficiency in nitrite and ammonium removal (Fig. 6).

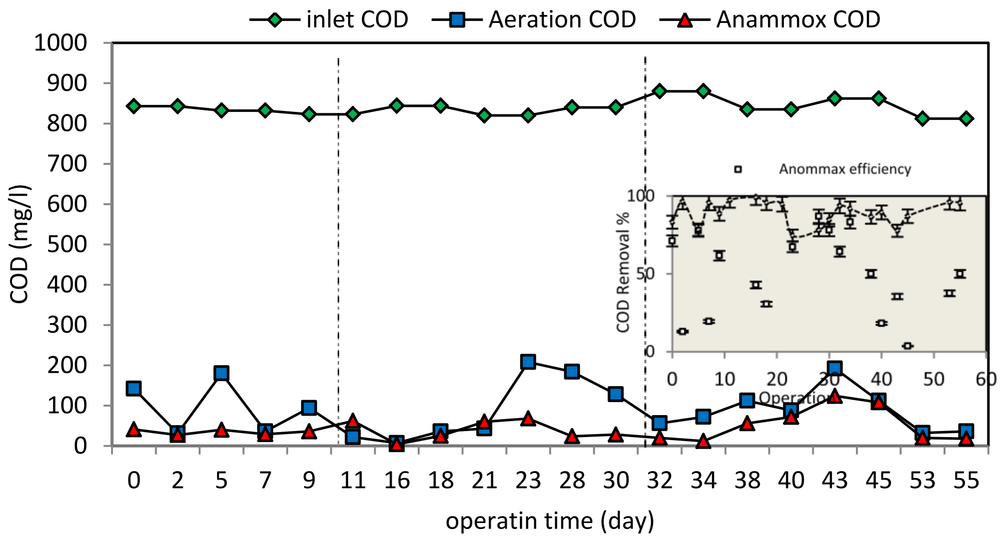

Fig-7: The removal efficiency of initial COD during the aeration and anommax process.

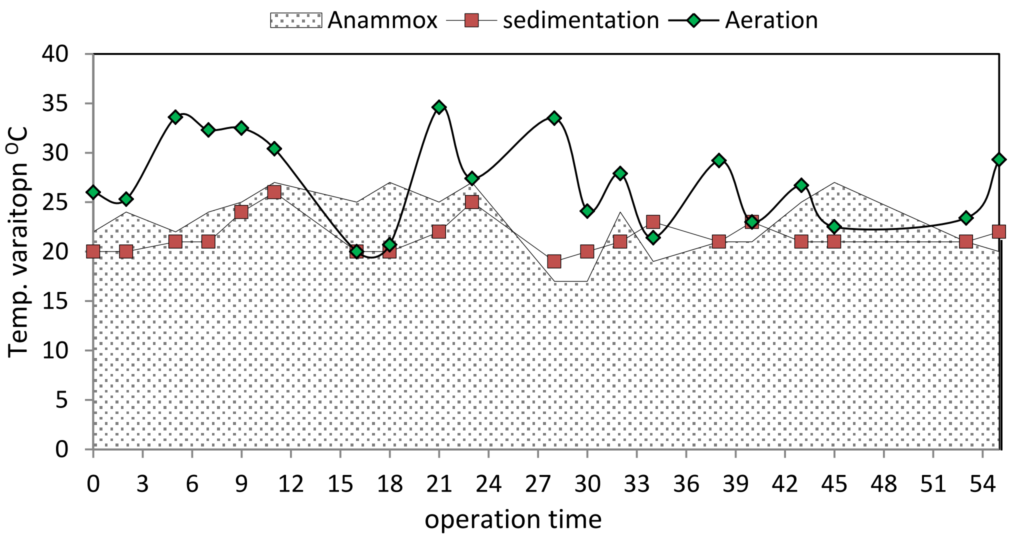

Fig-8: Variation of temperature during the aeration, sedimentation and anommax process.

The pH is a significant factor to monitoring the nitrite/ammonium ratio close to the desirable amount [3], and Park and Noguera (2004)[18] and Chuang et al. (2007) [19] have been suggested that the pH to be superior at nitritation and confidence of nitrite oxidation taken at 7.9–8.3. With regard to Fig.9 can be seen the fluctuant of pH with 5% of an error bar in theaeration tank that is shown the trend of pH during the three stages of operation. Furthermore, the NO_2/NH_4 ratio is illustrated in this diagram. Based on results, can be expressed the variation of the nitrite/ammonium ratio is dependence to pH conditions, and higher ratio of this parameter is associated to be higher pH in this tank. Thus, lower values of NO_2/NH_4have occurred with decrease of pH at third phase of anommax process.

4. CONCLUSIONS

Based on acquired results in present work can be expressed;

1. The aerobic activity of heterotrophic cultures can be decreased the most of the ammonium concentrations.
2. The developed nitrite rate is depended to initial load of NH_4.
3. The best amount pH for removal of nitrite and ammonium were occurred at pH 7.5-8.
4. Anommax process can remove the lower amount of COD and main port of COD was removed in the aeration process.

5. Temperature and pH are sensitive parameters in operating rather than other.

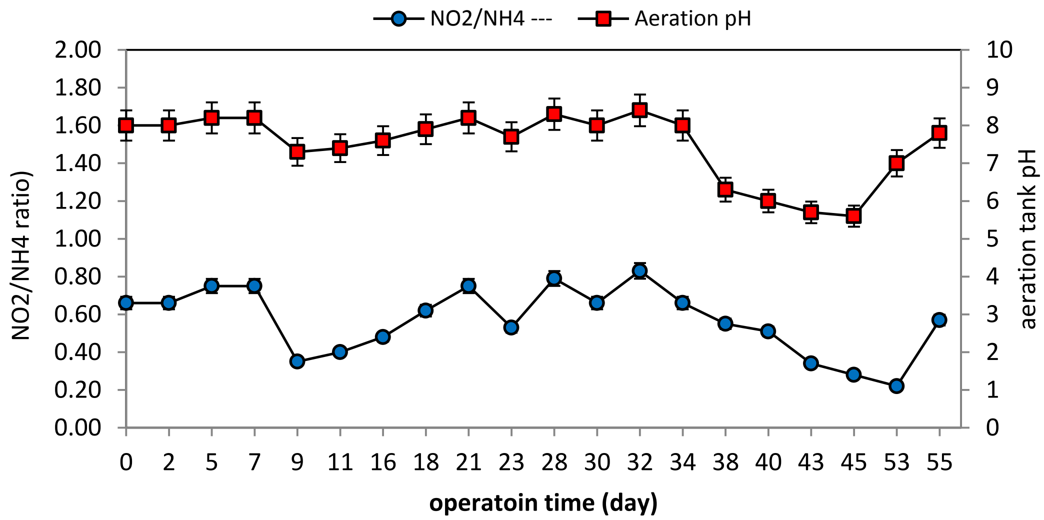

Fig-9: The trend of pH and NO_2/NH_4 ratio during the anommax process.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

1. Villaverde, S. F., Polanco, F., García, P. A., Wat Res, **(2000)**, 34(2): 602-610.
2. Jeison, D., Ruiz, G., Chamy, R., Water Research, **(2003)**, 37(6): 1371-1377, http://dx.doi.org/10.1016/S0043-1354(02)00475-X.
3. Fux, C., Boehler, M., Huber, P., Brunner, I., Siegrist, H., J. of Biotechnology, **(2002)**, 99(3): 295-306, http://dx.doi.org/10.1016/S0168-1656(02)00220-1.
4. Li, X. Z., Zhao, Q. L., Hao, X. D., Waste Management, **(1999)**, 19(6): 409-415, http://dx.doi.org/10.1016/S0956-053X(99)00148-8.
5. Demir, A., Gunay, A., Debik, E., Water, **(2002)**, 28(3): 329-336.
6. Ji, Z. Y., Yuan, J. S., Li, X. G., Journal of Hazardous Materials, **(2007)**, 141(3): 483-488, http://dx.doi.org/10.1016/j.jhazmat.2006.07.010.
7. Yang, Z., Sun, S., Zhou, Y., Journal of Hazardous Materials, **(2009)**, 169(1-3): 113-118, http://dx.doi.org/10.1016/j.jhazmat.2009.03.067.
8. Jin, R. C., Zheng, P., Journal of Hazardous Materials, **(2009)**, 170(2-3): 652-656, http://dx.doi.org/10.1016/j.jhazmat.2009.05.016.
9. Molinuevo. B., García. M. C., Karakashev D., Angelidaki, I., Bioresource Technology, **(2009)**, 100(7): 2171-2175.
10. Abma, W., Schultz, C., Mulder, J. W., Loosdrecht, M. V., Star, W. V. Der, Strous, M., Tokutomi, T., Water, **(2007)**, 21:36-37
11. Tsushima, I., Kindaichi, T., Okabe, S., Water Research, **(2007)**, 41(4): 785-794, http://dx.doi.org/10.1016/j.watres.2006.11.024.
12. Liu, S., Yang, F., Xue, Y., Gong, Z., Chen, H., Wang, T., Su, Z., Bioresource Technology, **(2008)**, 99(17): 8273-8279, http://dx.doi.org/10.1016/j.biortech.2008.03.006.
13. Güven, D., Dapena, A., Kartal, B., Schmid, M. C., Maas, B., Pas-Schoonen, K. van, de., Sozen, S., Mendez, R., Camp, H. J. M., Op, den, Jetten, M. S. M., Strous, M., Schmidt, I., Appl Environ Microbiol, **(2005)**, 71(2): 1066–1071.
14. Yossi, T., Joy, E. M. W., Schreier, H., J. Appl Environ Microbiol, **(2006)**, 72(4): 2896–2904, http://dx.doi.org/10.1128/AEM.72.4.2896-2904.2006.
15. APHA A. WPCF, Standard Methods for the Examination of Water and Wastewater. 21st ed. American Public Health Association: Washington, DC, **(2005)**.
16. Chamchoi, N., Nitisoravut, S., Chemosphere, **(2007)**, 66(11): 2225-2232, http://dx.doi.org/10.1016/j.chemosphere.2006.09.036.
17. Yan, J., Hu, Y. Y., Bioresource Technology, **(2009)**, 100(8): 2341-2347, http://dx.doi.org/10.1016/j.biortech.2008.11.038.
18. Park, H. D., Noguera, D. R., Water Research, **(2004)**, 38(14-15): 3275-3286.
19. Chuang, H. P., Ohashi, A., Imachi, H., Tandukar, M., Harada, H.,Water Research, **(2007)**, 41(2): 295-302.