

Research on the effectiveness of organic matter treatment of aerobic granular sludge On input wastewater At urban wastewater treatment plant

Nghiên cứu hiệu quả xử lý chất hữu cơ của bùn hạt hiếu khí đối với nước thải đầu vào tại trạm xử lý nước thải đô thị

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ABSTRACT

Urban wastewater in Vietnam is currently not collected and treated effectively. According to the latest report of the Ministry of Construction (2020), currently only 10 ÷ 15% of urban wastewater flow in Vietnam is collected and treated to meet discharge standards.

Popular wastewater treatment technologies in Vietnam include: activated sludge technology (CAS), sequencing batch reactor technology (SBR), Trickling Filter technology (TF), and oxidation ditch technology (OD), Moving bed bioreactor technology (MBBR), membrane bioreactor technology (MBR)... Application of aerobic granular sludge for urban wastewater treatment in Vietnam is at the laboratory research stage and has achieved results. The initial results were very good under the conditions in Vietnam.

In this paper, present the results of research on organic matter treatment (COD and $\text{NH}_4^+ - \text{N}$) using aerobic granular sludge for wastewater at Truc Bach treatment of Hanoi in a laboratory scale. The research was conducted on sequencing batch reactor (SBR) model with dimensions: tank diameter is 0.110 (m), height is 1 (m), working volume is 4 (liters). One working cycle is 3 hours, in a cycle consisting of 4 phases: water supply phase has 2 (minutes), aeration phase 130 (minutes), rest phase 30 (minutes), discharge phase 15 (minutes). Results: COD removal efficiency is always greater than 90%; $\text{NH}_4^+ - \text{N}$ removal efficiency is always greater than 75%.

Key word: Aerobic granular sludge; effective organic matter treatment; wastewater treatment.

TÓM TẮT

Nước thải đô thị tại Việt Nam hiện nay chưa được thu gom và xử lý hiệu quả. Theo báo cáo mới nhất của Bộ Xây dựng (2020) hiện tại mới có 10 ÷ 15% lưu lượng nước thải đô thị tại Việt Nam được thu gom và xử lý đạt tiêu chuẩn xả thải.

Các công nghệ xử lý nước thải (XLNT) tại Việt Nam phổ biến như: công nghệ bùn hoạt tính truyền thống (CAS), công nghệ xử lý theo mẻ (SBR), công nghệ lọc nhỏ giọt (TF), công nghệ mương oxy hóa (OD), công nghệ bùn hoạt tính dính bám (MBBR), công nghệ màng lọc (MBR)... Ứng dụng bùn hạt hiếu khí để XLNT đô thị tại Việt Nam đang ở giai đoạn nghiên cứu trong phòng thí nghiệm và đạt được kết quả ban đầu rất tốt trong điều kiện tại Việt Nam.

Trong nội dung bài báo này, trình bày kết quả nghiên cứu xử lý chất hữu cơ (COD và $\text{NH}_4^+ - \text{N}$) của việc sử dụng bùn hạt hiếu khí để XLNT tại trạm Trúc Bạch - Hà Nội quy mô phòng thí nghiệm. Nghiên cứu được thực hiện trên mô hình bể xử lý theo mẻ (SBR) có kích thước: đường kính bể là 0,110 (m), chiều cao bể là 1 (m), thể tích làm việc của bể là 4 (lít). Một chu kỳ làm việc của bể là 3 giờ, trong 1 chu kỳ gồm 4 pha: pha cấp nước vào có thời gian 2 (phút), pha sục khí 130 (phút), pha nghỉ 30 (phút), pha xả 15 (phút). Kết quả: hiệu quả loại bỏ COD luôn lớn hơn 90%; hiệu quả loại bỏ $\text{NH}_4^+ - \text{N}$ luôn lớn hơn 75%.

Từ khóa: Bùn hạt hiếu khí; hiệu quả xử lý chất hữu cơ; xử lý nước thải.

1. INTRODUCTION

Urban wastewater is a difficult problem for any country in the world, especially for countries with rapid urbanization like Vietnam. According to the World Bank report, Vietnam has an urbanization rate of 3 ÷ 4% per year [2]. With rapid urbanization, urban wastewater also increases rapidly in flow and pollution indicators. According to the latest report of JICA (2020) [3], currently only 10 ÷ 15% of urban wastewater flow in Vietnam is collected and treated to meet discharge standards. Urban wastewater treatment is an important issue to maintain sustainable development of the living environment. Popular wastewater treatment technologies in Vietnam include: activated sludge technology (CAS), sequencing batch reactor technology (SBR), Trickle Filter technology (TF), and oxidation ditch technology (OD), moving bed bioreactor technology (MBBR), membrane bioreactor technology (MBR),... These technologies have proven effective in treating urban wastewater and industrial wastewater in Vietnam. However, because urban wastewater in Vietnam is mostly collected by the combined sewer system, it has a low organic load [1]. Therefore, wastewater treatment technologies currently applied in Vietnam still face difficulties when wanting to thoroughly treat wastewater in Vietnam. Faced with that reality, finding a new technological solution for urban wastewater treatment in Vietnam is always of interest to scientists and managers. Application of aerobic granular sludge for urban wastewater treatment in Vietnam at the laboratory research stage and has achieved very good initial results under Vietnamese conditions.

In this study, experimental research is conducted on the use of aerobic granular sludge at Truc Bach wastewater treatment - Hanoi. The scope of research is laboratory scale. Experiment to evaluate the effectiveness of organic matter (COD và NH₄⁺ - N) treatment of aerobic granular sludge. The research on sequencing batch reactor (SBR) with diameter is 0.110 (m), height is 1 (m), working volume is 4 (liters). One working cycle of the tank is 3 hours, in a cycle consisting of 4 phases: the water supply phase has a duration of 2 (minutes), the aeration phase has 130 (minutes), the resting phase has 30 (minutes), the discharge phase has 15 (minutes). Wastewater has input COD ranging from 175 ÷ 210 (mg/l), NH₄⁺ - N input is 28 ÷ 58 (mgN/l). The study period is 30 days.

2. RESOLVE

2.1. Build experimental models

Research on a cylindrical SBR model made of acrylic plastic with tank diameter of 0.110 (m), height is 1 (m), working volume is 4(liters). In one day, the SBR tank works with 6 cycles, the duration of one cycle is 3 hours, the phases in a cycle are as follows: the water supply phase has a duration of 2 (minutes), the aeration phase has a duration of 130 minutes. (minutes), the settling phase has a time of 30 (minutes), the discharge phase has a time of 15 (minutes). Air is supplied into the SBR tank through an aerator system and a pumice air diffuser disc placed at the bottom of the SBR tank. The aeration flow gradually increases from 1.5 ÷ 5 (liters/minutes) during the experiment, on the gas pipeline, install a valve to adjust the aeration flow, the oxygen concentration during the experiment always ensures DO from 2 ÷ 4 mg/l. The water discharge valve is located 0.4 (m) from the bottom of the tank. Check pH and DO periodically, using a handheld meter, measuring once a day. All equipment such as wastewater pump, air blower, water discharge valve... are automatically controlled program according to experimental requirements.

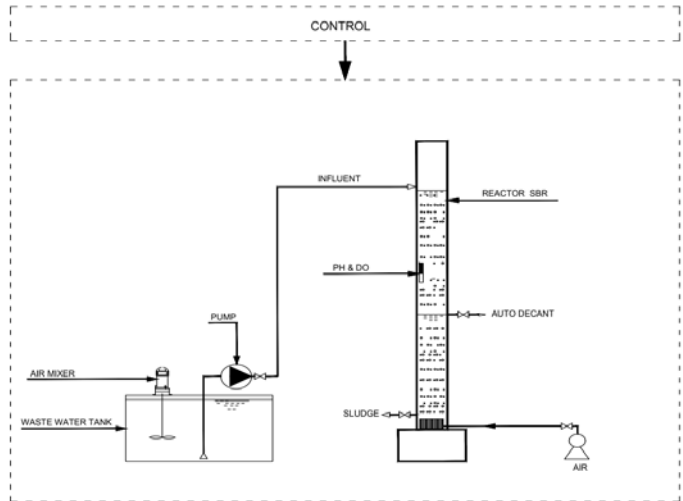


Figure 1. Pilot layout: geometric characteristics of reactors



Figure 2. Pilot in Laboratory

2.2. Experimental wastewater

Experimental wastewater is wastewater taken from Truc Bach wastewater treatment - Hanoi. Wastewater into tanks with a capacity of 20 (liters). Water after being taken from the wastewater treatment plant is stored in the laboratory refrigerator for a maximum storage time of 1 week. When running the experiment, the wastewater will be taken out and left for a while until the water temperature equals the laboratory temperature. The main components of wastewater are shown in the table below:

Table 1. Composition of organic substances in input wastewater

No	Analysis date	COD Input (mg/l)	NH ₄ ⁺ - N Input (mgN/l)	Note
1	The first day	189	29	Wastewater is taken from the regulation tank of Truc Bach Wastewater
2	2nd day	183	28	
3	3rd day	196	32	
4	4th day	178	37	

No	Analysis date	COD Input (mg/l)	NH ₄ ⁺ -N Input (mgN/l)	Note
5	5th day	210	54	Treatment
6	6th day	222	56	
7	7th day	206	53	
8	8th day	190	52	
9	9th day	182	46	
10	10th day	176	42	
11	11th day	212	40	
12	12th day	185	33	
13	13th day	193	35	
14	14th day	176	37	
15	15th day	178	38	
16	16th day	200	54	
17	17th day	182	58	
18	18th day	196	54	
19	19th day	180	52	
20	20th day	182	46	
21	21th day	199	42	
22	22th day	212	40	
23	23th day	205	37	
24	24th day	203	38	
25	25th day	206	36	
26	26th day	218	39	
27	27th day	200	54	
28	28th day	182	58	
29	29th day	176	51	
30	30th day	180	50	

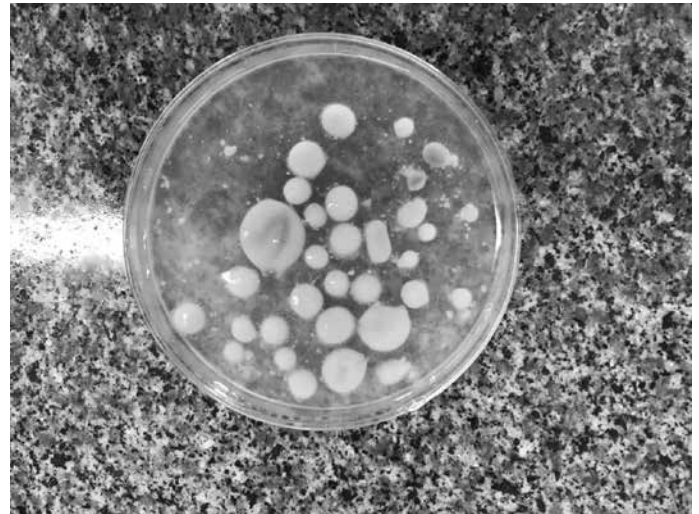


Figure 4. Experimental aerobic granular sludge

2.4. Operate the experimental model

Start the model and let it run automatically using the pre-installed program. Put 2.5 liters of prepared aerobic granular sludge into the model's reaction tank. After the model runs stably, start supplying wastewater taken from Truc Bach wastewater treatment station into the model's reaction tank. Maintain model operations according to pre-programming. Conduct daily inspections of equipment and valves, and take periodic samples as planned.

Model operating parameters are as follows: Experiment time is 30 days; DO oxygen concentration is 2.0 ÷ 4.0 (mg/l); Experimental temperature t0C is 25 ÷ 35°C; The pH is 6.1 ÷ 8.0.

2.5. Analyze experimental results

Parameters that will be analyzed during the research process include: COD index, NH₄⁺-N index. The indicators are analyzed according to Vietnamese Standards (TCVN) and are presented in the Table below:

Table 2. Parameters and analysis methods

Index	Unit	Analytical method	Analysis time
COD	mg/l	Photometric method, SMEWW 5220 - D:2012	Analyze once/day
NH ₄ ⁺ -N	mg/l	Follow the instructions of the device Method 10031 - Hach	
pH	-	Measured with sensor, handheld pH meter WTW 340i, Germany	Measure daily
DO	mg/l	Measured by sensor, handheld DO meter, Oron, USA	
Temperature		Electronic thermomete	

2.6. Result

a) COD removal efficiency

From the experimental results of aerobic granular sludge wastewater treatment, it can be seen that the COD removal efficiency in wastewater gradually increased after many days of experiment. The first 1 ÷ 5 days is the start-up phase of the model, the aerobic granular sludge added has not yet fully adapted to the



Figure 3. Wastewater collection at Truc Bach wastewater treatment - Hanoi

2.3. Experimental aerobic granular sludge

Aerobic granular sludge used for experiments is sludge that has been successfully cultured in the laboratory. The parameters of aerobic granular sludge are as follows: Mixed suspended solids index MLSS 8 (g/l), Mixed volatile suspended solids index, Mixed suspended solids index MLVSS/MLSS 79, 14%.

environment in the tank, so the treatment efficiency is not high, with a removal efficiency of 74 ÷ 88%. COD. In the following days, as the microorganisms in the granular sludge gradually adapted, the treatment efficiency also increased with the COD removal efficiency increasing from 88% to 92%. In the next stage, because the granular sludge has completely adapted to the experimental environment, the treatment efficiency is also stable and always maintained at a high level, with a removal efficiency of over 89 ÷ 92% COD. The COD removal results are shown in Figure 5 below:

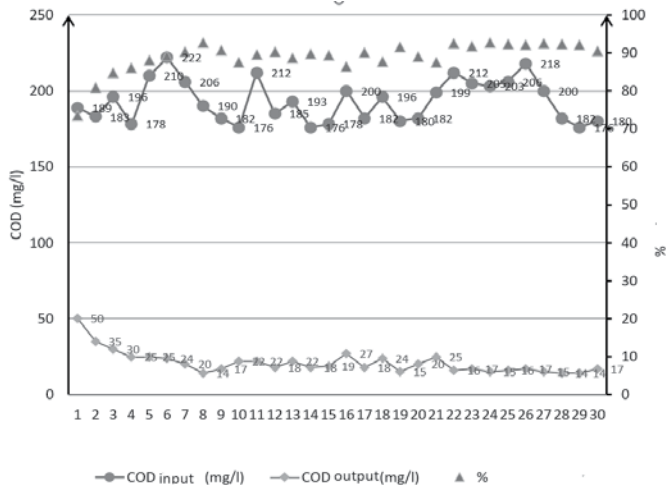


Figure 5. Results of COD remove

b) Effective removal of NH₄⁺ - N

The results of NH₄⁺ - N treatment of the experiment gradually increased. The first 1 ÷ 5 days is the start-up phase of the model, the aerobic granular sludge added has not yet fully adapted to the environment in the tank, so the treatment efficiency is not high, with a removal efficiency of 66 ÷ 73%. NH₄⁺ - N. In the following weeks, as the microorganisms in the granular sludge gradually adapted, the treatment efficiency also increased with the NH₄⁺ - N removal efficiency increasing from 73% to 75%. In the next stage, because the granular sludge has completely adapted to the experimental environment, the treatment efficiency is also stable and always maintained at a high level, with NH₄⁺ - N removal efficiency around 75%. The results of analyzing the NH₄⁺ - N index of input wastewater and output wastewater and treatment efficiency are presented in Figure 6 below:

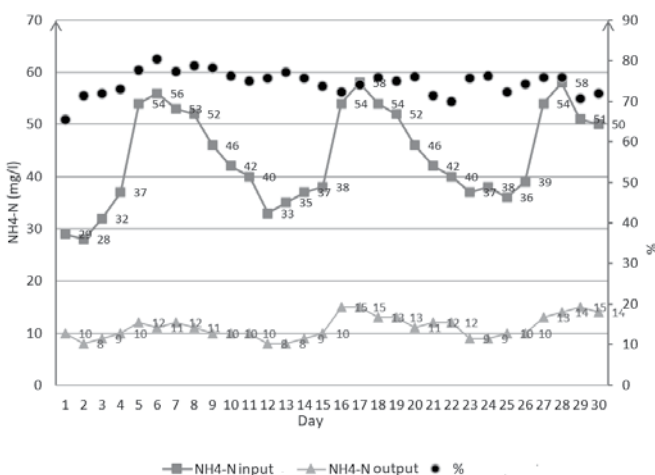


Figure 6. Results treatment NH₄⁺ - N

3. CONCLUSION

The organic matter removal efficiency of aerobic granular sludge when experimenting with urban wastewater taken from Truc Bach wastewater treatment station is very good. Stable removal results of over 90% COD, over 75% NH₄⁺-N.

Experimental results demonstrate that using aerobic granular sludge to remove organic substances in urban wastewater in Vietnam is completely feasible. This is the basis for other related research on wastewater treatment issues in Vietnam.

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