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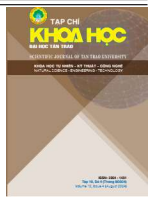

EVALUATION OF DOMESTIC WASTEWATER TREATMENT CAPACITY OF THE OXIDATION DITCH SYSTEM AT GIA SANG WASTE WATER TREATMENT PLANT, THAI NGUYEN CITY, THAI NGUYEN PROVINCE

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Abstract:

Through research and evaluation, we have some conclusions as follows: 1.The operation of the Oxidation ditch system in the first and second months is not really stable. Ammonium parameters (NH4+) in wastewater after treatment are very high at 19.13 to 19.42 mg/l, not meeting QCVN 14/2008 BTNMT. The parameters pH, BOD, TSS, TDS, Phosphorus, total coliform, etc. in treated wastewater all meet allowed standards. 2. After adjusting a number of operating parameters, the operation of the Oxidation ditch system in the months of March, April, May, June is quite stable, good treatment, all parameters to evaluate the quality of wastewater after treatment such as NH4+, NO3-, pH, BOD, TSS, PO43-, total Coliform all meet QCVN 14/2008 BTNMT. 3. The organic matter treatment efficiency of the Oxidation ditch system in the first six months of the year reached 83-100%. In January and February, the ammonium treatment efficiency is low, only reaching 39.6 to 41.9%, and in months March, April, May, and June, the efficiency is high from 90 to 100%.

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ĐÁNH GIÁ KHẢ NĂNG XỬ LÝ NƯỚC THẢI SINH HOẠT CỦA HỆ THỐNG MƯƠNG OXY HÓA TẠI NHÀ MÁY XỬ LÝ NƯỚC THẢI GIA SÀNG, THÀNH PHỐ THÁI NGUYÊN, TỈNH THÁI NGUYÊN

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Từ khóa:

Xử lý nước thải sinh hoạt, Mương oxy hóa, MOT, Xử lý sinh học hiếu khí, Xử lý sinh học thiếu khí

Tóm tắt

Để quá trình hoạt động của mương oxy hóa hoạt động đạt hiệu quả cao và ổn định việc theo dõi điều chỉnh các thông số vận hành cũng như đánh giá chất lượng nước sau xử lý là rất cần thiết. Qua nghiên cứu đánh giá chúng tôi có một số kết luận như sau: 1. Hoạt động của hệ thống MOT trong tháng thứ nhất và tháng thứ hai chưa thực sự ổn định. Thông số amoni (NH_4^+) trong nước thải sau sử lý rất cao là 19,13 đến 19,42 mg/l, không đạt QCVN 14/2008 BTNMT. Các thông số pH, BOD, TSS, TDS, Phốt pho, tổng coliform vv ở nước thải sau xử lý đều đạt quy chuẩn cho phép. 2. Sau khi điều chỉnh một số thong số vận hành hoạt động của hệ thống MOT trong các tháng 3, 4, 5, 6 khá ổn định, xử lý tốt, tất cả các thông số đánh giá chất lượng nước thải sau xử lý như NH_4^+ , NO_3^-, pH, BOD, TSS, PO_4^{3-}, tổng Coliform đều đạt QCVN 14/2008 BTNMT. 3. Hiệu suất xử lý chất hữu cơ của hệ thống MOT trong sáu tháng đầu năm đạt 83-100%. Tháng 1, 2 hiệu suất xử lý amoni thấp chỉ đạt 39,6 đến 41,9%, các tháng 3, 4, 5, 6 đạt hiệu suất cao từ 90 đến 100%.

1. Introduction

Oxidation ditch technology treats wastewater according to the activated sludge principle with aerobic and anoxic biological treatment mechanisms to remove organic substances and nitrogen in wastewater for the first time in 1950 in the Netherlands, and has now been widely applied in developed countries around the world such as France, Belgium, Germany …etc. Oxidation ditch technology chemical technology was transferred to Vietnam in the 90s of the 20th century. In Thai Nguyen province, Oxidation ditch technology began to be applied in recent years. For the Oxidation ditch operation to be highly effective and stable, monitoring and adjusting operating parameters as well as evaluating post-treated water quality is essential.

Based on the above reason, we conducted research on the topic *"Evaluation of the domestic wastewater treatment capacity of the oxidation ditch system at Gia Sang wastewater treatment plant, Thai Nguyen city, Thai Nguyen province"*. To evaluate the ability to treat domestic wastewater of the oxidation ditch system at Gia Sang Wastewater Treatment Plant in Thai Nguyen City, to detect the shortcomings and limitations of the system when it was first put into operation, thereby proposing solutions to overcome them, ensuring the wastewater treatment system operates effectively and stably.

2. Methods

- Directly survey and evaluate the operations of the oxidation ditch technology system and the operation of the treatment system. Adjust operating parameters when detecting parameters that evaluate the quality of the output water that do not meet standards.

- Sampling time: January, February, March, April, May, June.

- Untreated water sampling: on the second day of each month; Water sampling location at the reservoir.

- Treated water sampling of the oxidation ditch system: 3 consecutive days at the end of each month; Sampling location at the discharge of the disinfection tank.

- The post-treatment results are calculated based on the average of the parameters determined on 3 consecutive days.

- Water samples were analyzed and tested at the Center for Water Quality and Protection under the Ministry of Natural Resources and Environment (VILAS 1145-VIMCERT 218). Methods of water sampling, preservation and transportation according to current regulations of the Ministry of Natural Resources and Environment - VILAS 1145-VIMCERT 218. Total dissolved solids (TDS) are measured directly at the site using SOP 01.05

- Testing parameters and testing methods are according to current regulations of the Ministry of Natural Resources and Environment.

- Monitoring parameters: pH, BOD5, TSS, TDS, H2S, NH4+, NO3-, PO43-, ∑Coliforms of wastewater before treatment and after treatment.

3. Results and discussion

3.1. Overview of oxidation ditch system technology at Gia Sang Wastewater Treatment Plant, Thai Nguyen city.

The technology used to treat wastewater of Thai Nguyen city at Gia Sang Water Treatment Plant is the oxidation ditch system, with a designed treatment capacity of 8,000 m3/day and night.

The oxidation ditch system has two modules arranged in a zigzag pattern to increase ditch length as well as reduce construction area. Oxidation takes place along the length of the raceway based on agitator disturbance and direct aeration. Among them, there are two most effective reaction areas:

+ In the air blowing area, aerobic microorganisms will decompose organic matter and perform the nitrification process of NH4+ radical into NO3- radical.

+ In the sludge mixing area, the wastewater is completely mixed, increasing the contact between the sludge and the waste stream, where the process of reducing Nitrate (NO3-) to molecular Nitrogen gas (N2) takes place.

+ The oxidation ditch system has two radial settling tanks, two sludge dewatering machines, an automatic monitor for parameters such as pH, DO, EC of water, a channel system to measure input and output flow and a disinfection tank. (the disinfectant chemical here is javen).

+ Domestic wastewater from the centralized tank will be adjusted for pH and load if they are too high or too low, then pumped into the biochemical treatment system Oxidation ditch. At the oxidation ditch system, wastewater is treated by aerobic and anaerobic microorganisms, then the treated water is pumped to a radial sedimentation tank to separate sludge and pumped through a disinfection tank before being discharged into the environment.

3.2. Evaluation of the domestic wastewater treatment capacity of the oxidation ditch system at Gia Sang Wastewater Treatment Plant, Thai Nguyen City

3.2.1. Evaluation of the domestic wastewater treatment capacity of the oxidation ditch system

To evaluate the domestic wastewater treatment capacity of the oxidation ditch system at the Factory, we conducted monitoring of domestic wastewater samples before and after treatment in January, February, March, April, May, and June. From the analysis results, we evaluated the treatment capacity and stability during the trial operation of the oxidation ditch system.

The monitoring results in Table 1 show that the content of parameters of domestic wastewater before treatment is mostly within the allowable limits calculated according to column A of QCVN 14/2008. Only 3 parameters exceed the allowable standards, which are BOD5, total Coliforms and Amoni (by N): Amoni content (by N) is 31.68 mg/l, exceeding the allowable standard by 6.3 times; BOD5 is 73.1 mg/l, exceeding the allowable standard by 2.4 times; total Coliforms is 4,275 MPN/100ml, exceeding the allowable standard by 1.4 times.

The results in Table 1 also show that the quality of domestic wastewater after treatment by the oxidation ditch system has been significantly improved. In January, BOD5 decreased from 73.1 mg/l to 9.5 mg/l, Coliform decreased from 4,275 MPN/100ml to 950 MPN/100ml. In February, BOD5 decreased from 72.6 to 9.54 mg/l, Coliform decreased from 4,307 MPN/100ml to 1,163 MPN/100ml, within the allowable limit of QCVN 14/2008 BTNMT.

The ammonium content in the water after treatment decreased in the months, but they were still high at 19.13 mg/l to 19.42 mg/l and exceeded the allowable standard by 3-4 times. This shows that during the trial run, the ammonium content in the water after treatment did not meet the standard.

Table 1. Results of domestic wastewater treatment of the oxidation ditch system from January to March

No	Parameters	Unit	January		February		March		QCVN 14/2008 BTNMT (column A)
			Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	
1	pH	-	7.62	7.2	7.51	7.41	7.53	7.92	5-9
2	BOD_5	mg/l	73.1	9.5	72.6	9.54	15.3	<0.5	30
3	TSS	mg/l	17.4	10.7	17.9	10.3	11.1	2.4	50
4	TDS	mg/l	403	368	398	375	339	347	500
5	H_2S	mg/l	0.13	0.10	0.15	0.12	0,13	0.14	1.0
6	NH_4^+	mg/l	31.68	19.13	32.25	19.42	15.,11	<0.1	

No	Parameters	Unit	January		February		March		QCVN 14/2008 BTNMT (column A)
			Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	
7	NO_3^-	mg/l	< 0.1	2.35	<0.1	2.37	0.28	8.79	30
8	PO_4^{3-}	mg/l	4.40	2.25	4.6	2.38	4.70	2.	
9	∑Coliforms	MPN/ 100ml	4,275	950	4,307	1,163	1,830	1,100	3,000

Source: Research results

In March, April, May, and June, the aerostrip was adjusted to operate stably and at a suitable rotation speed for the anaerobic treatment process of bacteria in the ditch so that ammonium (NH4+) is converted to nitrate (NO3) => NO2 => NO => N2O => N2 evaporates. The results are also consistent with the studies of Ben Alaya, Chang ZiGuo and Pen Yongzhen, Xiaodi Hao.

Table 2. Results of domestic wastewater treatment of the oxidation ditch system from April to June

No	Parameters	Unit	April		May		June		QCVN 14/2008 BTNMT (column A)
			Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	
1	pH	-	7.72	7.49	7.82	7.68	7.76	7.59	5-9
2	BOD_5	mg/l	15.3	2.6	<5	<0.5	12.6	<0.5	30
3	TSS	mg/l	11.1	3.7	12.07	<1	10.4	<1	50
4	TDS	mg/l	359	335	362	335	358	320	500
5	H_2S	mg/l	0.15	0.11	0.15	<0.1	0.16	<0.1	1.0
6	NH_4^+	mg/l	15.11	1.46	17.00	<0.1	10.1	<0.1	5
7	NO_3^-	mg/l	0.28	4.42	0.40	5.4	1.34	8.9	30
8	PO_4^{3-}	mg/l	3.88	1.78	4.01	1.64	3.58	1.8	
9	∑Coliforms	MPN/100ml	1,830	1,326	1,700	970	1,580	1,020	3,000

Source: Research results

The results of monitoring the input wastewater in the months of April, May, and June in Table 2 show that the content of the monitored parameters is mostly within the allowable limits calculated according to column A of QCVN 14/2008 [5]. Only the Ammonium content (according to N) in the months exceeded the allowable standard by 2.0 - 3.4 times, this is also the most obvious characteristic of domestic wastewater in urban areas with high population density in the rainy season.

The ammonium content in the treated water in April decreased significantly from 15.11 mg/l to only 1.46 mg/l, meeting the permitted standard. However, when comparing the ammonium content in the treated water in April with that in March, it was much higher. This shows that the biochemical reactions of the oxidation ditch system were not really stable.

The ammonium content in the treated water in May decreased significantly from 17.0 mg/l to less than 0.1 mg/l.

Nitrate content in treated wastewater in all months increased higher than before treatment, increased the most in June from 1.34 mg/l to 8.9 mg/l. The reason is that the biochemical oxidation process of microorganisms occurred, converting a large part of nitrogen in the form of ammonium to nitrate. This form of nitrate nitrogen (NO3) has not yet been completely converted into molecular nitrogen (N2) during the treatment process due to lack of oxygen to evaporate. However, the remaining nitrate content in treated wastewater is much lower than QCVN 14/2008 BTNMT.

Thus, after 6 months of operation, the oxidation ditch system has gradually stabilized. The results of the environmental parameters of domestic wastewater after treatment such as BOD5, Amoni, Coliform all meet QCVN14/2008 BTNMT.

3.2.2. BOD5 and Ammonium treatment efficiency in domestic wastewater of MOT system

To see more clearly the ability of the oxidation ditch system to treat domestic wastewater, we determined the treatment efficiency of the system for some agents that can cause water pollution such as organic matter and ammonium nitrogen. The monitoring results are shown in the following tables.

Table 3. Treatment efficiency of organic matter (according to BOD5) in domestic wastewater of oxidation ditch system

Month	Input (mg/l)	Output (mg/l)	Performance (%)	QCVN 14/2008 BTNMT
1	73,1	9,5	87,	30
2	72,6	9,54	86,9	
3	15,3	<0,5	100,0	
4	15,3	2,6	83,	
5	<5	<0,5	100,0	
6	12,6	<0,5	100,	

Source: Research results

Table 3 shows that the organic matter treatment efficiency of the oxidation ditch system is relatively stable over the months, ranging from 83.0-100%. In April, the lowest treatment efficiency is 83%. In January and February, the treatment efficiency is 87%. In March, May and June, the treatment efficiency is 100%.

Table 4. Ammonium treatment efficiency (by N) in domestic wastewater of oxidation ditch system

Month	Input (mg/l)	Output (mg/l)	Performance (%)	QCVN 14/2008 BTNMT
1	31,68	19,13	39,6	5
2	32,25	19,42	41,9	
3	15,11	<0,1	100,0	
4	15,11	1,46	90,3	
5	17	<0,1	100,	
6	10,1	<0,1	100	

Source: Research results

Table 4 shows that the ammonium treatment efficiency (by N) in domestic wastewater of the oxidation ditch system in January and February was very low, reaching only 39.6 to 41.9%. This shows that the adjustment of aeration to provide oxygen for bacteria to convert nitrogen from ammonium to nitrate in the aerobic biochemical reaction zones in the ditch was not good.

After adjusting the aeration mode in March, the ammonium treatment results of the oxidation ditch in March, April, May, and June achieved high efficiency from 90 to 100%.

Through determining the domestic wastewater treatment efficiency of the oxidation ditch system in 6 months, it shows that the technology has gradually entered stable operation.

3.3. Existing problems and solutions to improve the efficiency of the oxidation ditch system at Gia Sang wastewater treatment plant, Thai Nguyen city

Through the time of researching and monitoring the operation of the oxidation ditch system at Gia

Sang Wastewater Treatment Plant in Thai Nguyen city, we have also drawn out some shortcomings and solutions to keep the Plant operating stably.

3.3.1. Problems during operation

+ Preliminary treatment, some raw waste still enters the inlet tank.

+ During the treatment process, primary treatment is rarely used, only extended aeration is used to nitrify and remove BOD. Here, extended aeration is used to minimize sludge production as well as provide a long period of time for endogenous sludge reduction.

+ Long sludge retention time in the initial stage to accumulate sludge to increase the number of microorganisms.

+ In the first 2 months, the amount of oxygen supplied for the biochemical oxidation process was low, so the ammonium content was still high in the water after treatment. In months 3, 4, 5, and 6, to speed up the nitrification process, the operator adjusted the aeration too high, leading to a high nitrate content in the water after treatment, which was not beneficial for the quality of the output water.

+ Aeration equipment - Aire - O2, brush-type rotating block, disc-type rotating block, Aerostrip sometimes did not operate stably, the rotation speed was not suitable for the substrate load in the tank, which sometimes led to local oxygen deficiency.

+ Automatic monitoring systems, the connection between the treatment system and the server in the operator's house sometimes disconnected for unknown reasons.

3.3.2. Remedial measures to improve the efficiency of operating the oxidation ditch system at Gia Sang Wastewater Treatment Plant, Thai Nguyen City

From the above existing problems in the operation of the oxidation ditch system at Gia Sang Wastewater Treatment Plant in Thai Nguyen City, we propose some measures to overcome the existing problems and improve the efficiency of the treatment system operation as follows:

+ Regularly check, at least twice a day, the trash screen system at the inlet of the tank. Periodically pump sand from the inlet wastewater tank to avoid accumulation of sand at the bottom of the tank and sand being sucked into the oxidation ditch.

+ Level 1 treatment only uses the extended aeration method to nitrify and remove BOD, so to ensure a suitable pH for microorganisms, it is necessary to have an automatic neutralizing agent injection mode during the process of pumping wastewater from the tank to the oxidation ditch.

+ Long sludge retention time in the initial trial run to accumulate sludge to increase the number of microorganisms. Therefore, after stable operation, it is necessary to recalculate the sludge retention time to suit the input substrate content and endogenous decomposition ability.

+ Ensure the amount of dissolved oxygen supplied for the nitrification process right from the beginning in the ditch to avoid the high ammonium content remaining in the water after treatment.

+ To reduce the nitrate content in the effluent, after a period of stable operation of the treatment system, it is necessary to rebalance the number of microorganisms belonging to the nitrification group so that the amount of nitrogen in the two forms of ammonium and nitrate remains in the water at the lowest content.

+ Monitor and adjust the aeration equipment - Aire - O2, brush-type rotating block, disc-type rotating block, Aerostrip to operate stably, the rotation speed is suitable for the substrate load in the tank to evenly distribute oxygen to avoid local oxygen deficiency.

4. Conclusion and Discussion

Through research, we have some conclusions as follows:

1. The operation of the oxidation ditch system in the first and second months was not really

stable. The ammonium (NH4+) parameter in the wastewater after treatment was very high at 19.13 to 19.42 mg/l, not meeting QCVN 14/2008 BTNMT. The parameters of pH, BOD, TSS, TDS, Phosphorus, total coliform, etc. in the wastewater after treatment all met the permitted standards.

2. The oxidation ditch system operated stably in March, April, May, and June; all parameters for evaluating the quality of treated wastewater such as NH4+, NO3-, pH, BOD, TSS, PO43-, and total Coliform met QCVN 14/2008 BTNMT.

3. The organic matter treatment efficiency of the oxidation ditch system in the first six months of the year reached 83-100%. The ammonium treatment efficiency in January and February was low, reaching only 39.6 to 41.9%. After adjusting the aeration mode, the ammonium treatment efficiency in March, April, May and June reached high efficiency from 90 to 100%.

REFERENCES

A.Stamou [*], A. Katsiri [*], I. Mantziaras [*], K. Boshnakov [**], B. Koumanova [**], S. Stoyanov (1999), *Modelling of an alternating oxidation ditch system.* Water Science and Technology. https://doi.org/10.1016/S0273-1223(99)00075-X

A. Cockx, N. Lesage, M. Spérandio, C. Lafforgue (2003), Calibration and Application of a 1-D Model for Oxidation Ditches. Chemical Engineering Research and Design. https://doi.org/10.1205/026387603770866470

Ben Alaya, Latifa Haouech, Hayet Cherif, Hedi Shayeb (2009), Eration management in an oxidation ditch. Access through your organization. https://doi.org/10.1016/j.desal..11.001

Chang Zi Guo, Wei Fu, Xue Mei Chen, Dang Cong Peng, Peng Kang Jin (2013), *Nitrogen-removal performance and community structure of nitrifying bacteria under different aeration modes in an oxidation ditch.* Water Research. https://doi.org/10.1016/j.watres.2013.04.005

Department of Water Resources Management - TCVN 7222:2002: *General environmental requirements for centralized wastewater treatment stations*. https://thuvienphapluat.vn/chinh-sach-phap-luat

J. Dudley (1995), Process testing of aerators in oxidation ditches, *Water Research,* https://doi.org/10.1016/0043-1354(95)00050

Peng Yongzhen , Hou Hongxun, Wang Shuying, Cui Youwei, Zhiguo Yuan (2008), Nitrogen and phosphorus removal in pilot-scale anaerobic-anoxic oxidation ditch system. Journal of Environmental Sciences. https://doi.org/10.1016/S1001-0742(08)62070-7

Pham Thanh Cong (2020), Evaluation of the domestic wastewater treatment ability of the MOT system at Gia Sang wastewater treatment plant, Thai Nguyen city, Thai Nguyen province. **Nong Lam University.** http://discovery.tnu.edu.vn/primo_library/

Shibin Xia, Junxin Liu (2004), An innovative integrated oxidation ditch with vertical circle for domestic wastewater treatment. Process Biochemistry. https://www.sciencedirect.com/science/article/pii

Thai Nguyen City Drainage and Wastewater Treatment Project Management Board (2009), Environmental impact assessment report «Thai Nguyen City Drainage and Wastewater Treatment Project»

Tran Kien (2022): *Oxidation ditch: Effective wastewater treatment facility in Industrial*

Park. Environmental technology electronic magazine, https://congnghiepmoitruong.vn /muong-oxy-hoa-cong-trinh-xu-ly-nuoc-thai-hieu-qua-trong-khu-cong-nghiep-9257.html**.**

United States Environmental Protection Agency, Office of Water Washington, D.C. (2000), *Wastewater Technology Fact Sheet Oxidation Ditches.* Office of Water Washington, D.C. https://www3.epa.gov/npdes/pubs/oxidation_ditch.pdf

William F. Ettlilch, (1978). *A Comparison of Oxidation Ditch Plants to Competing Processes for Secondary and Advanced Treatment of Municipal Wastes*. Environmental Protection Agency, Office of Research and Development, Municipal Environmental Research Laboratory, Wastewater Research Division ; Springfield, Va., 1978. https://nepis.epa.gov/Exe/ZyPURL

Xiaodi Hao, Hans J. Doddema, Johan W. an Groenestijn (1997), *Conditions and mechanisms affecting simultaneous nitrification and denitrification in a Pasveer oxidation ditch.* Bioresource Technology. https://doi.org/10.1016/S0960-8524(96)00143-5.