The assessment of technology SBR in Vietnamese wastewater treatment

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Abstract. The Sequencing Batch Reactor – SBR is a single reactor, uses “fill and draw” process for treating wastewater with activated sludge and has been around since the 1920s. In comparison with conventional continuous flow systems, SBR gets some advantages about operation, space requirement and cost. From 2012 – 2016 in Vietnam, 60% projects of urban wastewater treatment are SBR, including building new wastewater treatment plant or reconstruction for achievement Vietnamese discharge standard “The Standard A”. For assessment of application SBR technology for treating urban wastewater in Vietnamese conditions, examining 3 wastewater treatment plants (2 new plants and 1 reconstruction plant). The quality of treated water about suspended solids and organic pollution lower than discharge standard, but the concentration of nutrient is not achieved the Standard A or design value. The performance of the plant does not ensure when the population increasing in the near future.

1. Introduction

The Sequencing Batch Reactor (SBR) process is a Suspended Growth processes (with Activated Sludge), which all steps “Fill – Treat – Draw” occur in the same tank and operate in a cycle. Since 1920s the SBR are being used successfully to treat both municipal and industrial wastewaters. With the improvements in equipment and technology, SBR widely applied in the world such as in Europe, China and USA for treated wastewater form municipalities, resorts, casinos or areas characterized by low or varying flow patterns [1].

With the basic treatment process, SBR is a variation of the activated sludge process but it differ from Conventional activated sludge (CAS) reactors because all of the treatment steps are combined into a single tank. The difference is made from the hydraulic conditions of the wastewater’s flow in the structures, when the CAS operated with the constants of hydraulic loadings for each tank, the SBR filled during a discrete period of time and then operated as a batch reactor. All SBR have 5 steps for treated wastewater and carries out in sequencing as: Fill, React, Settle, Decant and Idle. The principle of cycle treatment in SBR and it differ from CAS are showing in Figure 1 [2].
Phase 1 Fill 2 React 3 Settle 4 Draw 5 Idle

Operation

Mixer and Air Mixed or Aerated Effluent Waste sludge

**Figure 1.** Principle of SBR and Comparison with Conventional activated sludge

According the Report about Vietnamese Urban Wastewater treatment and management from World Bank in 2012 [3], all of the wastewater treatment plants (WTTPs) in the big cities are used system CAS or Anaerobic system. And the quality of treated water about suspended solid or organic matter (BOD, COD) is lower, but their nutrient’s concentration (nitrogen, phosphorus) are always higher than the value of Vietnamese discharge standard – the Standard A (table 1) [4]. For archiving the Standard A with the requirement of treated water can be reused in agriculture and other services, from 2012 to 2016 the Vietnamese government has been building and reconstructing WWTPs. Most of WWTPs in the big cities of Vietnam choose SBR technology in the process biological wastewater treatment.

**Table 1.** Quality of waste water and treated water

| Parameters          | Influent of WWTPs | Effluent of WWTPs | Standard A |
|---------------------|-------------------|-------------------|------------|
| SS, mg/l            | 130 - 200         | 35                | 50         |
| BOD, mg/l           | 100 - 250         | 20                | 30         |
| COD, mg/l           | 150 - 300         | 45                | 50         |
| N-NH₄, mg/l         | 50 - 100          | 25                | 5          |
| P-PO₄₃⁻, mg/l       | 50 - 75           | 15                | 6          |

In the comparison between SBR and Conventional activated sludge system written by US EPA [5], the advantages of the SBR when applying in Vietnamese conditions can be summarized in 2 facts. At first, Vietnam is located in the South – East Asia near the Equator and has the tropical climate with 2 seasons per year: Dry and Rainy season. So the quality of Vietnamese wastewater into Combined Sewerage System depended on rainfall each season. The SBR control the wastewater treatment process, which change in the wide range of organic matter or nutrient, through adjustment phase time of each cycle. However, in the building or reconstructing WWTPs, the technology SBR reuses the material and instruments in the fact of Vietnam, where are applied system CAS because they are the variation of aeration process. It’s a most important thing in Vietnam, a developing country when the resources of financial, land or electrical can be reused to archive the discharge value [6].

2. Objectives, contents and methods

Nowadays Vietnam has proceed many projects for municipal wastewater treatment process but 60% project of urban WWTPs with the capacity higher than 30 000 m³/d was SBR. The SBR project in
Vietnam from 2012 to 2016 are showed in the table 2, including the new building and the reconstructing from another technology [7]

Table 2. Vietnamese urban wastewater treatment plans applied SBR technology

| No. | City          | WWTP      | Capacity (m³/d) | Status          |
|-----|---------------|-----------|-----------------|-----------------|
| 1   | Hanoi         | Yên Sở   | 210.000         |                 |
| 2   | Hanoi         | Hồ Tây  | 33.000          |                 |
| 3   | Hanoi         | Phú Đô   | 84.000          | under construction |
| 4   | Da Nang       | Phú Lộc   | 36.000         |                 |
| 5   | Da Nang       | Hòa Xuân | 40.000         |                 |
| 6   | Nghe An       | Vinh     | 50.000         |                 |
| 7   | Bàc Ninh      | Bàc Ninh | 30.000         |                 |
| 8   | Bàc Ninh      | Tư Sơn  | 30.000         |                 |
| 9   | Bình Dương     | Thù Dầu một | 35.000   |                 |
| 10  | Cần Thơ       | Cần Thơ  | 30.000         | under construction |
| 11  | Hochiminh City | Tham lương | 250.000     | under construction |
| 12  | Hochiminh City | Suối Nhun  | 65.000         | under construction |

With the assistances of Environmental Protect Research Center, Danang University of Technology, assessing the application of technology SBR under Vietnamese conditions. Objective evaluation included the new wastewater treatment plant (WWTP) – the 5th and 7th plant and the reconstructed plant – the 4th plant on the table. The main content of assess is surveying system treatment, analyzing the quality of influent and effluent of WWTPs and evaluating the performance of SBR reactor. The parameters for observation WWTPs include: BOD5, COD, N – NH4, N – T and phosphorus. Process analyzing wastewater quality has been conducted at laboratory of EPRC by Standard Methods for the Examination of Water and Wastewater [8].

3. Results and discussion
3.1. The new WWTP applies SBR:
The applications of SBR in the new WWTPs in Vietnam can be found at Hoaxuan (No.5) and Bacninh (No.7), used on municipal wastewater treatment with designing capacity is 30 000 m³/d. These plants utilize 2 tanks SBR, which operate in parallel under Continuous – flow system (Figure 2). After mechanic treatment, the wastewater treats only into tank 1 or tank 2, and when the tank 1 receives the influent from the clarifier, the other one operates in Settle phase and will be ready for the Filling phase. It is ensuring process biological treatment in SBR reactor when the influent gets the peak flow.
In 2016, these plants only operated for a half of their capacity, from 15 000 – 20 000 m3/d and the quality of treated water has been showed in graphic

Figure 3. The influent and effluent of SBR in WWTP Hoaxuan and Bacninh

The graphic showed that, the pollutions in influent of WWTPs have been changed in a large range for 1 year. In the effluent, the concentration BOD5 and COD achieved the Standard A but the nutrients’ concentration did not reached that. The performance for nutrification and nutrient removal in the SBR is not good with the efficiency varies from 30 – 50 % for Nitrogen and 20 – 60% for Phosphorous.

However, in 2016 the WWTP only operates from 15 000 – 20 000 m3/d, and this capacity by a half of design value, from 30 000 – 40 000 m3/d. So in the near future, when the incoming flow rate of WWTP increasing, the efficiency of organic removal will be decrease and concentration BOD and COD of effluent cannot achieve the Standard A. The relationship between removal efficiency and operating capacity of 2 WWTPs showed in Figure 4
3.2. *The reconstructed WWTP applies SBR*:
The second target of assessing the application of technology SBR under Vietnamese conditions is a reconstructed WWTP. In the WWTP No.4, the SBR has been changed the anaerobic lagoon since July 2017 with an average daily flow of municipal wastewater 30 000 m3/d. The Figure 5 showed the changing of system treatment, which the SBR has been built in the fundament of No.3 in the old system.

Figure 4. The relationship between removal efficiency and operating capacity
Old treatment system: 1 Screen; 2 Grit removal; 3 Anaerobic lagoon; 4 Sanitation

New treatment system: 1 Screen; 2 Primary clarifier; 3 SBR; 4 Sanitation

Figure 5. The comparisons of old and new treatment system on reconstructed WWTP

From 16 to 23 August 2016, we took a survey on the reconstructed WWTP, sampled and examined the influent and effluent of SBR reactor. The results of them can be showed on the table

Table 3. Results of analysis SBR reactor

| Parameters       | 16/8 | 17/8 | 18/8 | 19/8 | 20/8 | 21/8 | 22/8 | Design value |
|------------------|------|------|------|------|------|------|------|-------------|
| BOD\textsubscript{s}, mg/l | 7.6  | 8.7  | 9.3  | 8.8  | 7.9  | 7.5  | 8.4  | 8           |
| COD, mg/l        | 17   | 21   | 24   | 23   | 22   | 20   | 24   | 20          |
| N-NH\textsubscript{4}, mg/l | 8.3  | 9.6  | 7.9  | 8.1  | 9.1  | 9.3  | 8.7  | 6           |
| T – N, mg/l     | 14.3 | 15.8 | 15.5 | 16   | 15.7 | 15.3 | 15.4 | 15          |
| T – P, mg/l     | 1.8  | 1.7  | 1.6  | 1.6  | 1.5  | 1.6  | 1.8  | 1.6         |

In comparison the effluent’s quality with Standard A and the Design value of WWTP, the area graphic has been build (Figure 6) and the situation of SBR reactor summarized as follows: About organic matters, the SBR reactor easy to achieve the Standard A and the BOD and COD concentration of effluent approximately the design value. However, process nitrification and phosphorus removal in the reactor are still not good, with the concentration nitrogen – ammonia and the total phosphorus are higher than Standard A or Design value.
Figure 6. The comparisons of Standard A, Effluent and Design value in reconstructed WWTP

4. Suggestions
From the results of 3 WWTP with SBR technology in biological treatment process, this reactor got 2 problems under municipal wastewater of Vietnamese conditions. Firstly, the performance of SBR is not good at present and will be decrease when the capacity increasing in the near future. After that, the concentration of nutrient cannot achieve the Standard A, because efficiency of nutrification and nutrient removal does not reach the designing.

Therefore, it is necessary to optimal process nutrification and nutrient removal and increasing their performance in SBR reactor under Vietnamese conditions. On over the world have many methods for Modifications of the SBR, including technical method or upgrade devices. The technical method will applies the attached material into SBR to increasing the performance of process nutrient removal, and the other method will decrease the hydraulic loadings for SBR reactor in the Reaction phase.

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