ADVANCED WASTEWATER TREATMENT BY HYDRAULIC AUTOMATIC FLOATING MEDIA FILTER

Tran Thanh Son*, Pham Van Duong

Hanoi Architectural University. Department of Water Supply and Sewerage. km 10, Nguyen Trai street, Thanh Xuan district, Ha Noi city, Viet Nam

*Email:*shonlaanh@yahoo.com*

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ABSTRACT

A pilot scale experiment was carried out in tertiary wastewater treatment using hydraulic automatic floating filter. The hydraulic automatic floating media filter has been working with 120 cm depth of polystyrene bed. Wastewater from secondary biological treatment of WWTP was treated in the pilot filter with filtration velocity of 4 m/h. Oxygen concentration was remained constantly at level 2.0 mg/l by using an ejector. Headloss development and evaluation of SS, COD, NH_4^+ removals during filtration were objectives of the study. The experiment results showed that concentrations of SS, COD and NH_4^+ in effluent wastewater were kept lower than 5 mg/l, 30 and 0.5 mg/l respectively for almost filtration cycle. Effects of treatment in SS, COD and NH_4^+ were 88.27 %, 68.54 % and 5.59 %, respectively.

Keywords: headloss, COD removal, SS removal, NH_4^+ removal, hydraulic automatic floating media filter.

1. INTRODUCTION

Primary and secondary wastewater treatment is able to remove the majority of organic substances (BOD) and Suspended Solids (SS). However, in many cases this level of wastewater treatment does not meet National Technical Regulation of wastewater discharge. Thus, additional treatment steps have been implemented to wastewater treatment plant (WWTP) for further removal of organic substances and solids or nutrient and/ or toxic substances [1]. In this concept, filtration facility is used as tertiary treatment. In advanced wastewater treatment, rapid sand filters are widely used for removal of organic substances (BOD) and suspended solids (SS) [2]. Because of developing of plastic material technology, floating polymer material filters application in water and wastewater filtration is more and more popular [3]. In this article, floating polymer material is called floating media or floating filtered media and the study was carried out in tertiary wastewater treatment using hydraulic automatic floating filter.

Literature review showed that filters with floating media have been developed in USSR (Russia, Ukraine) in water and wastewater treatment since 1961. Firstly, polystyrene was used as filter's material for rapid filtration. Those filters are marked as FPZ (ФПЗ –Фильр с

плавающими загрузками) which work with floating media of polystyrene [4]. Later other materials of polymer were used as filter media like polyurethane, propylene, Capron (nylon), polyethylene [4]. In the years of 70-x and 80-x of century 20th, there were number of floating media filters developed in China, Czech Republic, Japan and other Europe countries [5]. At the end of 80-x, the first research and application of filter with floating media were noted in Vietnam [6]. The most application of FPZ was in water supply treatment. For advanced domestic wastewater treatment, the filter FZP is used as tertiary treatment to meet National discharge standard.

In other countries, there are some researches on filter operation using floating media, but the development of this filter on a commercial scale was limited to wastewater treatment application [7]. The Bio Styr [Omnium de Trainments et de Valorisation OTV of France] or the uplow floating aerated biofilter has filter bed of submerged and floating granular polystyrene. This wastewater treatment process incorporated features of the classical biological filter and of upflow filtration. According to the literature review, it is also suggested that resin beads made of foamed polystyrene are more suitable for an upflow filter than either polyethylene or polypropylene because of their lower density and substantially greater buoyancy in water. The polystyrene is inert and pose no health hazard [7].

The objective of the research was to check the removal efficiencies of SS, COD and ammonium nitrogen ($N\text{-}NH_4^+$) and headloss rate which is most important for hydraulic automatic floating media filters.

2. MATERIALS AND METHODS

2.1. Experimental setup

Experiment carried out in wastewater treatment plant (WWTP) in Youngone Industrial zone, Namdinh province, Viet Nam. Influent wastewater from secondary biological treatment of the WWTP has following characteristics (in average meaning) described in Table 1.

Table 1. Average values of influent wastewater into hydroautomatic floating filter.

N	Characteris-tics of wastewater	Unite	From secondary treatment (influent)	Note : Quality of wastewater [8]
1	COD	mg/l	63,3±5	does not meet QCVN 40 :2011/BTNMT. All category A, B.
2	SS	mg/l	28,72±3	meet QCVN 40 :2011//BTNMT. Category A, B.
3	NH_4^+	mg/l	0,72±0,2	meet QCVN 40 :2011/BTNMT. All category A, B.
4	pH	-	7,5±0,3	meet QCVN 40 :2011 /BTNMT. All category A, B.
5	T^o	^oC	26±3	meet QCVN 40 :2011/BTNMT. All category A, B.

The schematic diagram of experimental setup is shown in Figure 1. The treated domestic wastewater (1) from secondary biological treatment plant in was fed to one pilot model of hydraulic automatic floating media filter.

Hydraulic automatic floating filter made from stainless steel 304 with diameter D = 300 mm equipped vertical acrylic glass window to watch inside. Influent wastewater (1) pumped through ejector (2) with flow q = 0.28 m^3/h that filter worked with filtration rate at 4 m/h. Ejector (2) mixed wastewater with air to maintain oxygen concentration in the filter is about 2 mg/l. The depth of floating polystyrene media was 120 cm. Headloss was increasing during filtration, which was fixed by Piezometer Panel (8). When headloss got maximum level (top of siphon), filter started backwashing process by clean water from tank (6) through siphon (10). Online control equipment (9) for concentration of SS, COD, NH_4^+ in mg/l as well as pH and temperature (oC) of wastewater. Flow control is regulated by valve and flow was measured by special tank and watch. Intensity of backwashing is designed about 10-12 l/s/m2 with backwashing time of 4 - 5 minutes.

It is important note that the wastewater treatment technology in Youngone IZ is biological nutrient removal (N, P removal). From the data in Tab.1, it is noted that some parameters do not satisfy National Technical Regulation of wastewater discharge (QCVN 40 :2011/BTNMT). The most important pollutants which needed to remove are COD, SS and NH_4^+.

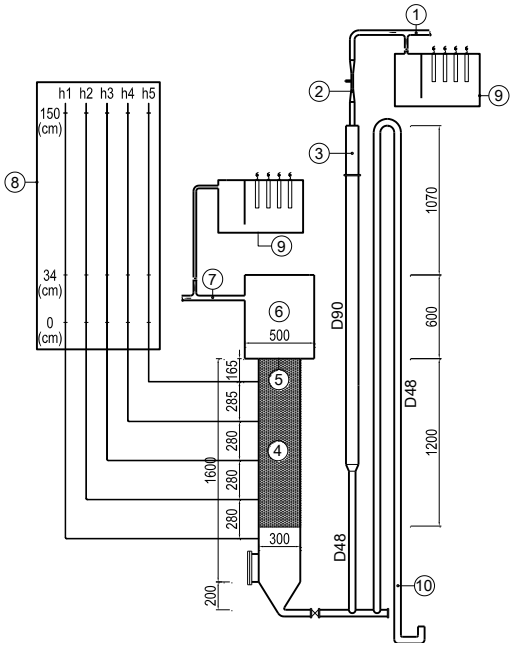

Figure 1. Pilot model of hydraulic automatic floating media filter for advanced wastewater treatment. (1) influent of wastewater from secondary biological treatment ; (2) ejector ; (3) hydraulic pressure stabilizator; (4) polystyrene filter media bed ; (5) grit ; (6) backwashing tank ; (7) effluent of treated wastewater ; (8) Piezometer Panel; (9) Online control facility (q, COD, SS, NH_4^+) ; (10) Backwashing siphon.

Wastewater come from secondary biological treatment had following average characteristics : (1) COD = 63.3 mg O_2/l; (2) SS = 28.72mg/l ; (3) NH_4^+ = 0.74 mg/l.

Polystyrene granular material which used in the experiment play a role as a filter granular media which has been used in Tran's research project [7]. The filter media has effective diameter De = 1.22 mm, coefficient of heterogeneity Kd (d80/d10) = 1,38, density of the polystyrene floating filter media 45 kg/m3 and porosity 40 %. According to the researched result [6], the polystyrene granular meet other requirement tests like chemical resistance and mechanical strength for filtration materials.

The experiment was carried out with filtration velocity of 4 m/h for a filter's cycle. The objective of this experiment is to evaluate the removal efficiencies of the pollutants and headloss rate with filtration velocity of 4 m/h for future research and optimization on filter's work.

2.2. Analytical methods

Online control for SS, COD, NH_4^+, pH and temperature were carried out by automatic monitoring station at Young one wastewater treatment plant. The pilot module is under control of and Natural Resources and Environment Monitoring and Analysis Centre, Nam Dinh Department of Natural Resources and Environment at 192, Cu Chinh Lan street, Nam Dinh city.

3. RESULTS AND DISSCUSION

3.1. Effluent concentration of pollutants

The experiment carried out in March 29th, 2017 and finished in April 3rd, 2017. Filter's cycle has been operated almost for 104 hours and finished when backwashing started. The results of the experiment are presented in Figure.2.

The experiment results showed that concentration of SS in effluent wastewater was kept lower than 5 mg/l for almost 80 hours of filtration. After 80 hours of filter's operation, SS concentration was fluctuated around 5 mg/l. Concentration of the SS got more than 10 mg/l at the end of 104 hour's operation when backwashing started automatically.

The most interesting behavior is COD concentration change during filtration. At the beginning of filter's cycle, COD concentration has been fluctuating between 30 and 25 mg/l for more than 5 hours, after that it was smoothly decreasing for 70 hours (from 10 hours moment to 80 hours moment). It could be explained by biochemical process in filtration when activated sludge particle accumulation was enough in filter media body [7].

Concentration of NH_4^+ was fluctuated at level of 0.5 mg/l and 0.7 mg/l at all time of filter operation. It showed that nitrification was not occurred. There may be explained that a small concentration of NH_4^+ in influent (0.8 mg/l) and not enough of nitrification bacteria fraction attached on polystyrene filter media because of short time operation (104 hours).

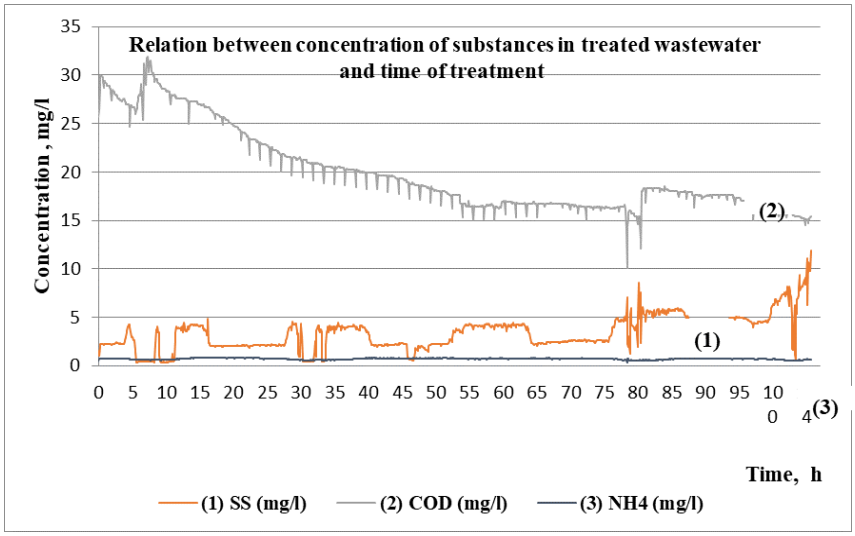

Figure 2. Relationship between SS, COD and NH_4^+ concentration in effluent treated wastewater and time of filtration.

3.2. Headloss development

The research results showed headloss development with different depth of filtration bed in Figure 3.

There different depths of floating bed setup for measurement of headloss as well as for taking samples for analyses were 120, 101, 87, 59, 31 cm. The initial headlosses of all filter's depths were around 20 cm.

During operation time (104 hours), total headloss got maximum level at 140 cm (the top of the siphon). As observed, the headloss development within filter media was liner (Figure.3). The average headloss rate was 1,15 cm per hour.

Results of headloss development showed that slope of graphic line according to media depth of 31 cm up to media depth of 120 cm was increasing. The line number 5 of 31 cm depth media bed was remained constantly as intitial headloss level. The line number 5 is horizontal and its slope is zero. It showed that there was almost no SS - accumulation in this layer (top layer near grid). The slope of line number 1 of 120 cm media layer is biggest in compare with other graphic lines (2, 3, 4, 5).

Based on theory of filtration and graphic analyzing, there was concluded that about 50 % SS accumulation in the first 30 cm filter media layer. It is noted that in the study the filtration cycle of 104 hours was 8,3 times as long as usual filtration cycle of 12 hours. According to the headloss development (Figure 3.), the effective filtration cycle could be designed more than 104 hours because concentrations of SS, COD and NH_4^+ in effluent treated wastewater were still lower than the values of the standard of QCVN 40 :2011/BTNMT [8]. Subsequently, it could lead to reduce bachwashing water volume as well as operational cost so much.

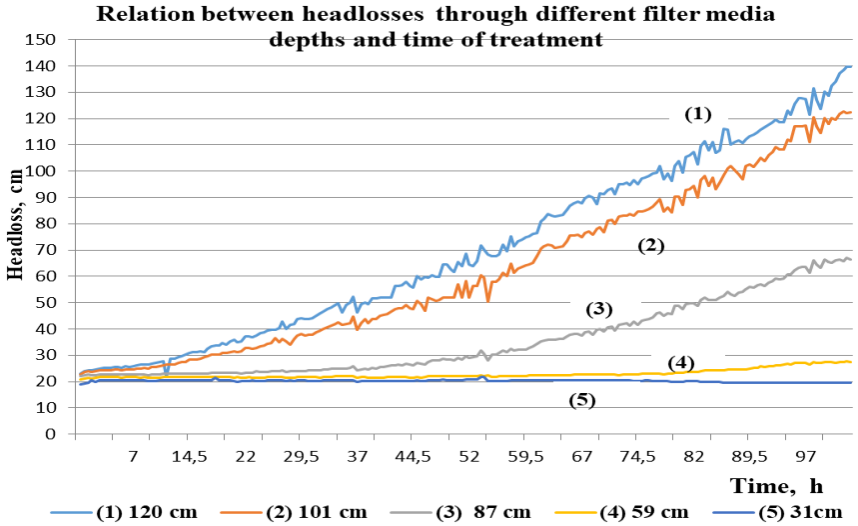

Figure 3. Headloss development during filter operation cycle (filtration velocity v = 4 m/h).

3.3. Effectiveness of tertriary treatment

Experimental results showed that effects of treatment in SS, COD and NH_4^+ were 88.27 %, 68.54 % and 5.59 % respectively (Figure 4.). There is note that after advanced treatment, all concentrations of SS, COD meet standard of discharge QCVN 40 :2011/BTNMT [8] and QCVN 08 :2015/BTNMT [9].

Concerning NH_4^+ concentration, it meets QCVN 40 :2011/BTNMT but not QCVN 08 :2014/BTNMT. However, treated wastewater could be reused for some purposes like street and machinery washing and cleaning, agriculture needs.

4. CONCLUSION

Experiment showed that effectiveness of wastewater treatment could be achieved with hydraulic automatic floating media filter to meet National Technical Regulation of wastewater discharge. Removal effeciciencies of COD and SS removal are hight while removal effeciciency of NH_4^+ is low.

Operation characteristics of hydraulic automatic floating media filter at the regime of 4m/h filtration velocity were that, headloss rate of 1.15 cm per hour; filter cycle of 104 hours or 4.3 days; backwashing rate and time of 10 -12 l/s/m^2 and 4- 5 minutes, respectively.

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