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ADVANCED DOMESTIC WASTEWATER TREATMENT TECHNOLOGY BY SELF- BACKWASHING FILTER BASED ON FLOATING MEDIA

SPECIALTY: INFRASTRUCTURE ENGINEERING

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INTRODUCTION

1. The necessity of the theme

Wastewater pollution in urban rivers and lakes has been a serious social issue in Vietnam cities. Over the past ten years, many urban and industrial wastewater treatment stations, most of which are designed with post-treatment water quality requirements at level B, QCVN 40:2011/BTNMT or QCVN 14:2008/BTNMT, have been invested for construction. The maintenance and assurance of post-treatment water quality to meet current specifications are often not achieved due to objective reasons such as both qualitative and quantitative changes in daily water discharge regime and subjective reasons about the applied technology or non-compliance with constantly operational regulations on wastewater treatment stations, causing pollution of rivers and lakes. Recently, the Ministry of Natural Resources and Environment and the local authorities have requested wastewater discharging units to upgrade and supplement technologies and equipment for wastewater quality to meet level A of the above mentioned specification.

Therefore "the theme "Advanced domestic wastewater treatment technology by self-backwashing filter based on floating media" is very actual and urgent. The study results of the dissertation that can be referred and applied to upgrade existing or newly built wastewater treatment stations for post-treatment wastewater quality improvement reaching level A of QCVN 40:2011/BTNMT or QCVN 14:2008/BTNMT.

2. Objectives of the study

Develop the technology making domestic wastewater completely treated with self-backwashing filter based on floating media for application into the reality.

3. Contents of the study

- Overview of domestic wastewater treatment technology and floating material filters for completed wastewater treatment,

- Definition Theoretical basic definition of SS, COD, BOD and N removals;

- Physical pilot modeling and experimental implementation;
- Technological filtering parameters (a, b) and reaction constant (k) determinations;
- Theoretical calculation establishment for self -backwashing filter based on floating media as tertiary treatment for SS, COD, BOD and N removals;
- Development and application of new wastewater treatment technology to build real wastewater plant with capacity 150 m3 per day as well as scientific evaluation for its work.

4. Subjects and scope of the study

a) Subjects of the study

Advanced domestic wastewater treatment process in self-backwashing filter based on floating media.

b) Scope of the study

Physical pilot experiments on real domestic wastewater and study on new built wastewater treatment plant q=150 per day with new developed self-backwashing filter unite using floating media.

5. Methodology

There were scientific methods used as following: scientific inheritance, theoretical analysis, experimental and technological simulation on physical model, mathematical modelling and data analysis.

6. Novelty of the study

The research results showed that self -backwashing filter based on floating media could be applied to the traditional wastewater treatment plant as advanced treatment unite after biological secondary treatment that effectively works both for mechanical and biological processes.

Experimentally, kinetic and technological parameters of advanced wastewater treatment filtration after biological secondary treatment were found:

- Mechanical filtration process: SS breakout coefficient (a) and cohesion coefficient (b) corresponding to filtration rate: 5-10m/h

- Biological filtration process: First order reaction rate constants of COD, BOD, NH_4^+, total nitrogen removals:: k_{BOD} = 0.08; k_{COD} = 0.075; k_{NH4+} = 0.082; k_{TN} = 0.042.
- Calculation method for designing self-backwashing filter based on floating media, applied for advanced wastewater treatment after biological secondary treatment.

7. Scientific and practical meaning of the thesis

The dissertation has established scientific methodology for researching and developing quite new advanced treatment unite. The research was carried out in the following sequence: theoretical hypothesis, methodological support, experimental research, processing of primary information and evaluation of the results, formation of an adequate model of the process, conclusion, application into real object.

Based on experimental results, the dissertation has proved high efficiency of the advanced treatment unite in according to the basic criteria in Vietnam water quality standards QCVN 14: 2008/BTNMT. Kinematic parameters and technological reaction constants of treatment process with self-backwashing filter based on floating media in advanced domestic wastewater treatment have also been identified.

Based on the experimental results, the dissertation has successfully designed and developed advanced treatment wastewater plant system into reality with self- backwashing filter based on floating media, which has capacity in 150 m^3 per day, the capacity of which is 150 m^3/ day & night, with self-cleaning floating material filters.

8. Structure of the thesis

In addition to the introduction, conclusion, recommendations and annexes, the thesis consists of 3 chapters:

- Chapter 1: Overview of domestic wastewater treatment technology with self-cleaning floating material filters.
- Chapter 2: Scientific bases for treatment of domestic wastewater biologically treated at the second order with self-cleaning floating material filters.

- Chapter 3: Experimental study on the completed treatment of domestic wastewater biologically treated at the second order with self-cleaning floating material filters.

CONTENT

CHAPTER 1: OVERVIEW OF COMPLETED DOMESTIC WASTEWATER TREATMENT TECHNOLOGY WITH SELF-CLEANING FLOATING MATERIAL FILTERS

1.1. Completed domestic wastewater treatment technologies using biological methods

1.1.1. Treatment technology using both Nitrogen and Phosphor biologically

Flow charts often used include: (1) A2/O process, (2) Five-level Barenpho process, (3) UCT process and (4) VIP.

1.1.2. Nitrogen treatment technology with biological measure

Removing BOD and ammonium nitrogen separately or step by step; or simultaneously removing organic compounds (based on BOD) and ammonium nitrogen ($NH4^{+}$-N).

1.2. Floating material filters in wastewater treatment technology

1.2.1 Traditional floating material filters

There are various types: FPZ-1; FPZ-2; FPZ-3; FPZ-4; FPZ-5, FPZ4-N; AFPZ-5M; FPZ-COMPACT-2; FPZ COMPACT- 10 ; Compack – 6; Biological submerging aeration filter BAF.

1.2.2 Self-cleaning floating material filters

Self-cleaning floating material filters with 2 syphons; Bio-reactors combined with self-cleaning floating material filter AFPZ-4; other combined self-cleaning floating material filters; Self-cleaning floating material filters with concentric syphon AbioF.

1.3. Floating material for filters

1.3.1 Floating Polystyrene material

Studies, during works operation with floating polystyrene for 20 years, have not found any change in physicochemical components of particles. In Vietnam, polystyrene standardization was conducted based on the State-level research topic of Assoc.Prof.PhD Tran Thanh Son. There are two types of useful diameters: De = 3.19 mm và De = 1.22 mm.

1.3.2 Floating material used in submerged biological reactors

Moving bed biological reactors are one of the most developed technologies in recent years. K1 and K2 are common types today.

1.4. Overview of studies, applications, and patents related to floating material filters for completed domestic wastewater treatment

1.4.1 Relevant studies

Pham Ngoc Thai "Study on floating material filters in water supply and drainage for small objects and the military."

Nguyen Van Tin "Study on floating material filters in the technological line of underground water deionization using aeration methods for low-capacity stations.

Tran Thanh Son "Study on self-cleaning floating material filters for domestic water treatment" and "Completed wastewater treatment in biological reactors with adhesive masses".

Nguyen Thanh Phong "Study on self-cleaning floating filters for small water supply stations"

ϕ degaard. H et al "Study on advanced treatment level 3 with floating material filters."

H. H. Ngo and S. Vigneswaran "Experiments of wastewater treatment at level 3 with floating material filters."

Weimin Xie et al showed experiments of wastewater treatment at level 3 with filters using polystyrene.

Hitoshi Miyaki et al used floating filters as the treatment works at the first order and Nano filters (NF) as those at the second order.

B. Rusten et al studied new submerged aeration biological filters (SABF) using suspended polymer.

M. Payraudeau et al studied the impact of temperature and organic loads based on COD to the third order nitration in floating material biological reactors with filter direction from the bottom up.

Frank Rogalla and Marie-Marguerite Bourbigot, "Completed removal of organic substances simultaneously combined with N treatment through submerged aerated biological filters."

N. Puznava, M. Payraudeau and D. Thornberg, regarding biological aerated filters (BAF) for treatment of Nitrogen, nitration and simultaneous denitrification process.

Taira Hidaka, Hiroshi Tsuno, Naoyuki Kishimoto used biological filters with submerged floating material fixed and aerated for completed treatment.

Jinwoo Jeong, Taira Hidaka, Hiroshi Tsuno, Toshiyuki Oda regarding the application of biological filtration process for the third order treatment to improve the efficiency of floating material and nitrogen treatment.

A.T.Mann et al mentioned the mathematical simulation for biological aerated filters (BAF) with floating polystyrene.

Allan T. Mann et al found that biological aerated filters (BAF) are able to integrate (i) biological treatment and (ii) removal of suspended substances (SS) in a filter.

Rebecca Moore, Joanne Quarmby and Tom Stephenson showed that biological aerated filters (BAF) are an attractive solution for future treatment technologies.

Leopoldo et al also indicated that BAFs can make simultaneous treatment of ammonium and organic compounds including carbon and suspended substances (SS) in the same filter.

Some patents of especially designed floating material filters

The patent of Andrew K. Hsiung, Corvallis and Oreg is an invention of self-cleaning floating material filters. Invention code: 4.547.286 granted by the U.S

The patent of Ronald F. Malone is about biological floating material filters. Invention code: 5.126.042 granted by the U.S.

Also, one more patent from Ronald F. Malone Invention code: 5.232.586 granted by the U.S.

1.4.2 Practical applications of floating material filters for completed wastewater treatment

Floating material filters have been applied in some wastewater treatment plants in Ukraine and Russia for completed domestic wastewater treatment. However, there has not been any research or scientific works on technological parameters of applied floating material filters.

In Vietnam there is no summarized study or scientific announcement about technological parameters.

1.5. Key issues for solution in the thesis

Generally, references have found that there are many types of self-cleaning filters like as floating material filters AbioF widely studied and applied with only freshwater, not wastewater. Biological reactors in general and floating material filters in particular are capable of removing suspended substances (SS), BOD and nutrients when making the third order treatment. Studies showed that maintaining dissolved oxygen concentration at (DO) = 4-5 mg/l in biological reactors could avoid inhibition of nitrification. Study results of A.T.Manm et al indicated that reaction at the first order was suitable with biochemical process of floating material filters. Nitrification process in floating material filters in case of short contacting time was possible but there were no certain results. The filter speed in completed wastewater treatment was very different. Increasing loss has not mentioned in studies. Self-cleaning floating material filters can be combined with others (biological reactors) to form a set of hydraulic self-cleaning filters. The following issues need to be more studied:

Study on the removal process of SS, BOD, COD and nutrients, pressure losses toward self-cleaning floating material filters for completed wastewater treatment.

Study on finding out technological parameters (speed of increased losses, filter cycle, filter coefficients a and b) of self-cleaning floating material filters for completed wastewater treatment in different filter velocity.

Study on specifying kinematic parameters of biological treatment process of dissolved organics like as BOD, COD and nutrients (ammonium, nitrogen).

Study on developing the theory of self-cleaning floating material filters for simultaneous removal: (1) SS and BOD; (2) SS, BOD, ammonium, total nitrogen. From which, optimizing technological parameters such as thickness of filter materials, filter velocity, filter cycle, etc.

Studying on trial application of study results to the reality to prove the technological efficiency.

CHAPTER 2: SCIENTIFIC BASES FOR COMPLETED TREATMENT OF DOMESTIC WASTEWATER BIOLOGICALLY TREATED AT THE SECOND ORDER WITH FLOATING MATERIAL FILTERS

2.1. Components of domestic wastewater

Domestic wastewater consists of pollution components such as nitrogen (90%), phosphate (80%), potassium (80%), COD (70%), drug residue, hormone and pathogens.

Domestic wastewater is the key reason for organic substances such as BOD, Nitrogen and phosphor to invade.

2.2. Vietnamese and international discharge standards

Summarize documents that require post-treatment wastewater output from European countries, Russia, Singapore, Japan and Vietnam. It is found that Japanese regulations are at the highest level. European regulations are among those of Japan and Russia. Vietnamese specifications are at the bottom of the survey table.

2.3. Selection of floating material for completed domestic wastewater treatment

From above studies and applications, polystyrene standardized in Vietnam has been selected with diameter d=1.22mm for this study.

2.4. Theorical basis on treatment of suspended subtances (SS) in filters.

2.4.1. The rule of SS filter process through material layer

The SS filtration efficiency at each filter layer is the result of two opposite processes: (1) SS residue separated from the water and attached to the surface of filter material particles under the impact of adhesive force; (2) separation of SS particles attached to the surface of filter material particles to transfer them back into the water under hydrodynamic effects.

The core task of the study on water filtration process is to specify the protection time of filter material layer (T_{bv}).

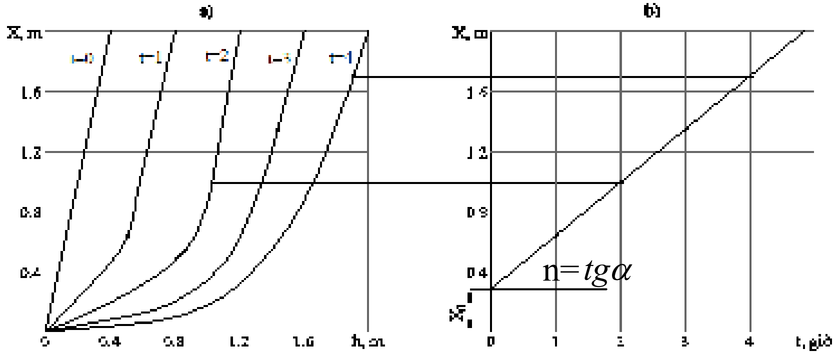
2.4.2. Differential equation of SS filter process through granulated material layer

$$\frac{\partial^2 C}{\partial x.\partial \tau} + a.v.\frac{\partial C}{\partial x} + b\frac{\partial C}{\partial \tau} = 0 \qquad (2.9)$$

This differential equation describes the water filtration process via granulated material layer. In order to define filtration parameters, a and b from differential equation (2.9) it can be done by experiments.

2.4.3. Method to specify filtration parameters and the protection time

a) *Define filtration parameters, a and b by experiments*



$$b = \frac{X_0}{x_0} \text{ và } \frac{a}{b} = \frac{n}{k} \qquad (2.10)$$

Figure 2.6. The graph of head pressure change based on filter material thickness and the protection time, t

b) *Define the protection time of filter material layer.*

$$T_{bv} = \frac{1}{k}.\frac{\mathrm{b}}{\mathrm{a}}.\left(x - \frac{\mathrm{X}_0}{\mathrm{b}} \right) \qquad (2.11)$$

According to documents, after specifying the protection time of filter material, the filter cycle (T) can be defined in compliance with the following formula: $T_{bv} = (1{,}2 \div 1{,}3)$ T.

c) The relationship between filtration parameters, a and b, the diameter of filter material, d of different filter velocity, v specified according to the following formula:

$$b_2 = b_1 \left(\frac{v_1}{v_2} \right)^{0,7} . \left(\frac{d_2}{d_1} \right)^{0,7} \qquad (2.\ 12)$$

$$\left(\frac{a}{b} \right)_2 = \left(\frac{a}{b} \right)_1 . \left(\frac{v_2}{v_1} \right)^{1,7} \left(\frac{d_2}{d_1} \right)^{0,7} \qquad (2.13)$$

2.5. Theoretical bases of biological treatment process through biological reactors

2.5.1. Removal of carbon organic compounds

Removal of carbon organic compounds includes 3 phases: biomass growth of heterotrophic microorganism; endogenous respiratory process; hydrolysis process of slowly biodegradable organics.

2.5.2. Nitrification

Nitrification is a critical part in metabolic activities of autotrophic microorganism groups and inorganic nitrogen compounds. The progress is taken place in two continuous steps:

Step 1: The energy taken from oxidation reaction will change 4
ammonium N-NH_4^+ into nitride NO_2^-.

Step 2: Oxidizing NO_2^- into NO_3^- and considered as the energy power for the growth of micro-organism.

2.5.3. Denitrification

The denitrification process consists of two steps:

Step 1: Nitrate is eliminated to nitride with two electrons moved from the organic oxidation to nitrate (NO_3^-);

Step 2: Nitride is continuously eliminated to the final product in order as follows:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO^- \rightarrow N_2O \rightarrow N_2$$

2.5.4. Anaerobic ammonium nitrogen oxidation (Anammox)

Anaerobic ammonium nitrogen oxidation was discovered by Mulder in 1992, and registered the copyright in 1995 (*Mulder et al.*

1995, 1992). At that time, the anaerobic ammonium nitrogen oxidation was named *Anammox*. The impact of micro-organism on anaerobic ammonium nitrogen oxidation was studied in the late 1990s. (*Jetten et al. 1999, 2001*).

$$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$$

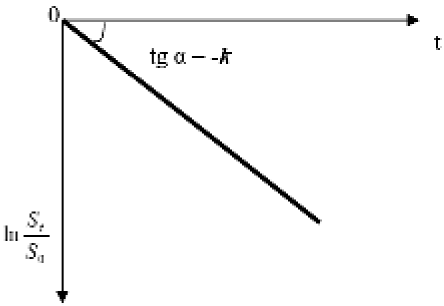


Figure 2.9. Define the constant of the first-order reaction rate in the coordinate system (ln (St/So), t)

2.5.5. *Identify kinematic parameters of the biological treatment process*

General documents have shown that the kinematic theory of chemical reaction [Eckenfelder, W.W. 1996] is suitable with submerged biological filters and also selected for test results.

The equation of biochemical reaction rate in differential form:

$$v = -\frac{dS}{dt} = kS^m \quad (2.26)$$

Regarding the first order equation (m=1):

$$\frac{S_t}{S_0} = e^{-k.t} \quad (2.35)$$

In this case, the first order equation is the line in the coordinate system (*$ln(S_t/S_0)$, t)*, the tangent of inclination is the constant of substrate recycle velocity (see *Figure 2.9*)

CHAPTER 3: EXPERIMENTAL STUDY ON THE COMPLETED DOMESTIC WASTEWATER TREATMENT AFTER THE SECOND ORDER BIOLOGICAL PROCESS BY SELF-CLEANING FLOATING MATERIAL FILTERS

3.1. Development of a research model

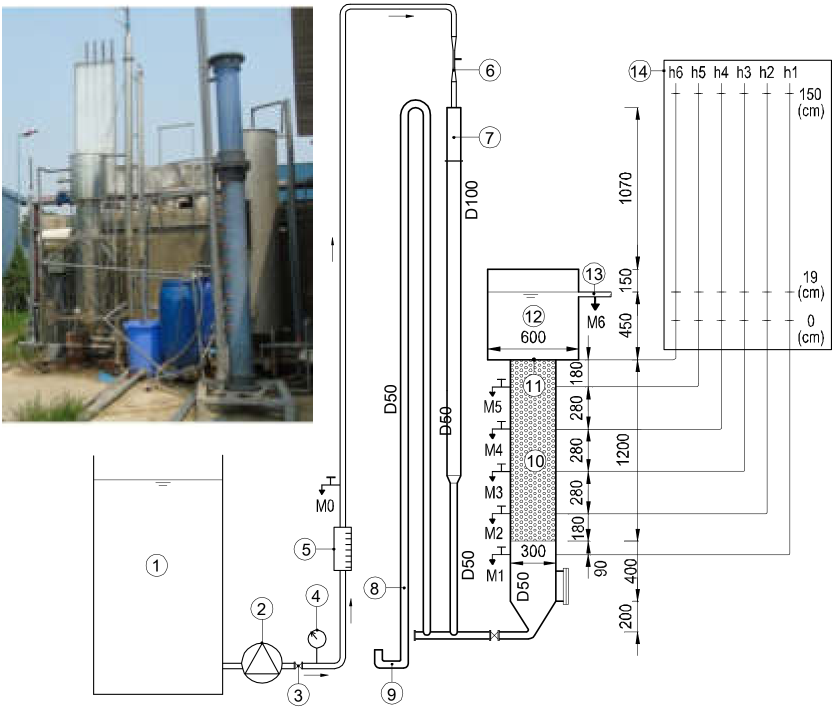


Figure 3.1: Testing model of self-cleaning floating material filters for completed domestic wastewater treatment

(1) Wastewater tank from the second settling basin; (2) Wastewater pump; (3) Flow control valve; (4) Pressure gauge; (5) Flow meter; (6) Ejector ; (7) Pressure stabilizing pipe;(8) Hydraulic siphon; (9) Hydraulic lock; (10) Filter material; (11) Filter screen; (12) Filtered water tank; (13) Post-treatment wastewater; (14) Pressure gauge table;

Operational principle of the testing model

After biologically treated at the second order, wastewater from the second settling basin is taken to the tank (1). Water in the tank (1) is pumped under high pressure through the ejector (6), in which, wastewater is mixed with the air.

After going through the ejector, water pressure decreases suddenly at the head pressure (7). The O2 enriched water mixture flows into the contacting filter material layer, causing biological treatment process to be taken place in filters, while SS residue is retained in the filter material layer. Dissolved concentration of O2 is maintained with 4-5 mg O_2/l thanks to the ejector; and pH = 7-9, temperature t = 20^0C-30^0C, alkalinity of 100 - 200mg/l CaCO3 is maintained by operation of the treatment station where testing equipment is installed.

Location of the testing model

The testing model is located at the domestic wastewater treatment station with the capacity of 800m^3/day&night by Young One Nam Dinh Co., Ltd in Hoa Xa Industrial Zone, Nam Dinh City, Nam Dinh province. The second order biological works at the wastewater treatment station is an aerotank.

Testing duration

Starting from July 26, 2016 to May 28, 2017.

3.2. Operational procedures and objectives of experimental studies

3.2.1. *Study on the completed wastewater treatment process with self-cleaning floating polystyrene filters.*

Identify the efficiency of completed domestic wastewater treatment based on parameters such as SS, COD, BOD_5, NH_4^+, total Nitrogen, PO_4^{3-} of self-cleaning floating material filters. Also, define the rule of increasing the head pressure of filters.

Determine filtration intensity

Determine the relationship between the filtration intensity and the expansion of floating material.

3.3. Study results of the completed wastewater treatment process with self-cleaning floating polystyrene filters

3.3.1. Test result with v = 5 m/h.

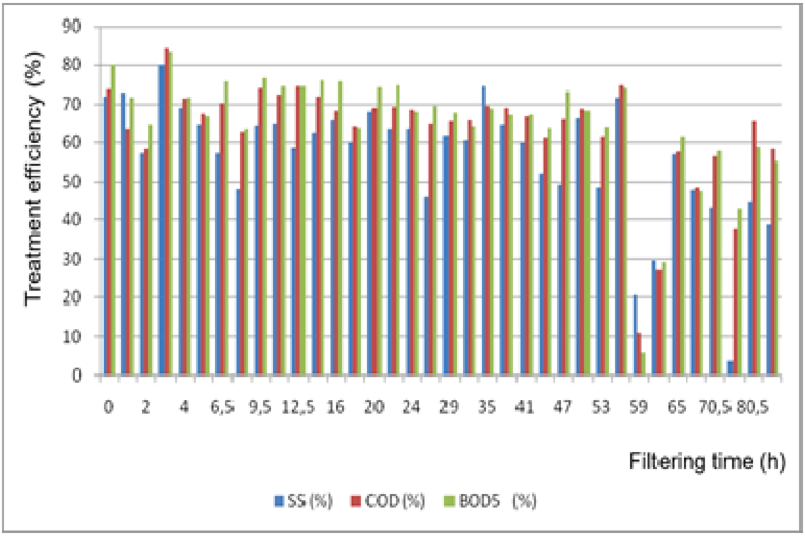


Figure 3.11: The diagram of treatment efficiency of SS, COD, BOD_5 (v = 5m/h)

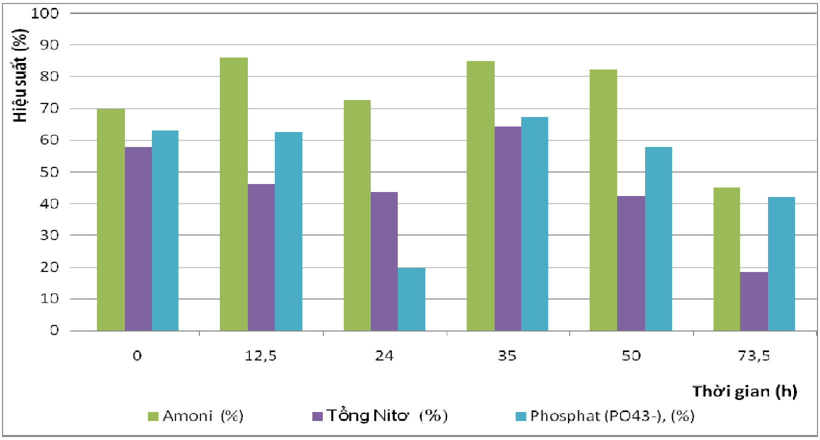


Figure 3.12: The diagram of treatment efficiency of NH_4^+, total Nitrogen, PO_4^{3-} (v=5m/h)

- The equation of increasing losses with v = 5 m/h is as follows:

$$\Delta h = 0.01t^2 + 0.527t + 3.559$$

3.3.2. Test result with v = 7,5 m/h

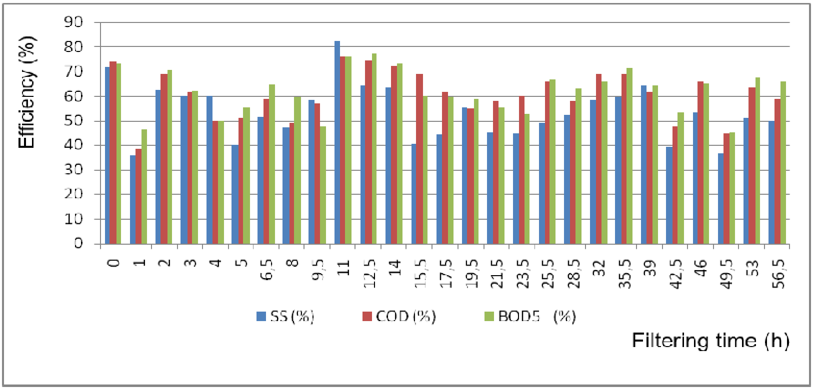


Figure 3.21: The diagram of treatment efficiency of SS, COD, BOD5 (v=7.5m/h)

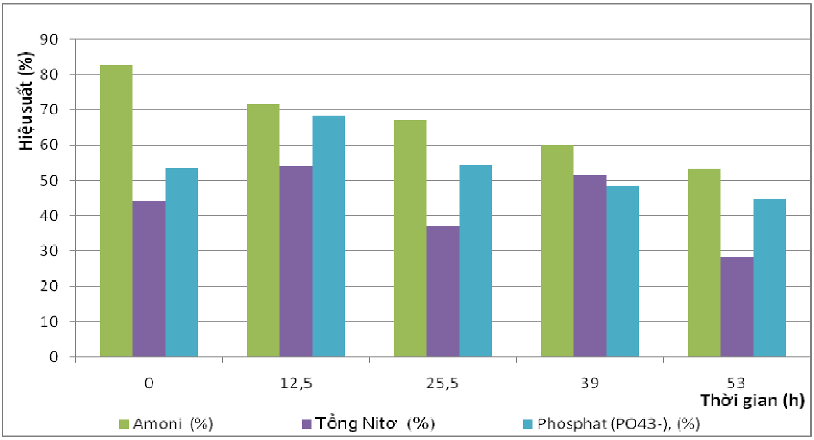


Figure 3.22: The diagram of treatment efficiency of NH_4^+, total of Nitrogen, PO_4^{3-} (v=7.5m/h)

- The equation of increasing losses with v = 7.5 m/h is as:

$$\Delta h = 0.007t^2 + 0.041t + 5.16$$

3.3.3. Test result with v = 10 m/h

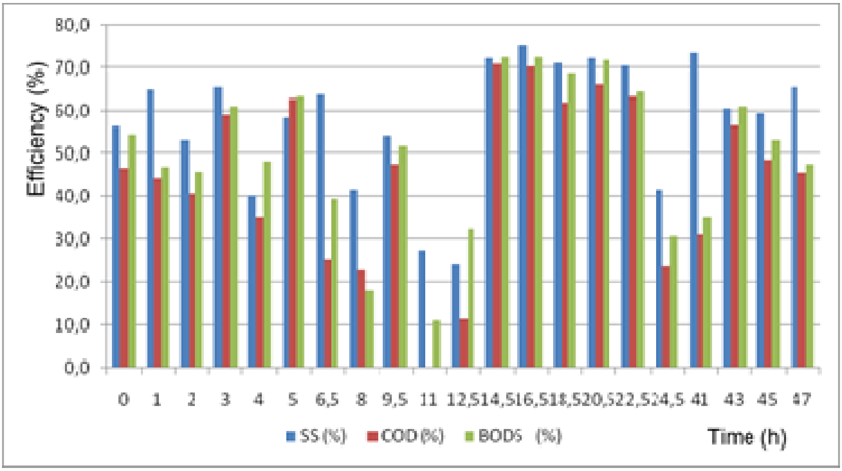


Figure 3.31: The diagram of treatment efficiency of SS, COD, BOD_5 (v = 10m/h)

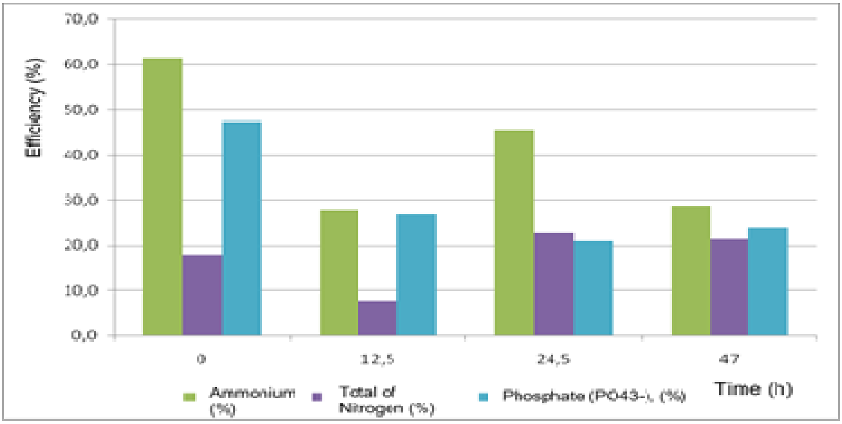


Figure 3.32: The diagram of treatment efficiency of NH_4^+, total Nitrogen, PO_4^{3-} (v=10m/h)

- The equation of increasing losses with v = 10 m/h is as follows:

$$\Delta h = 0.049t^2 - 0.101t + 10.92$$

3.3.4. Test result with v = 12.5 m/h

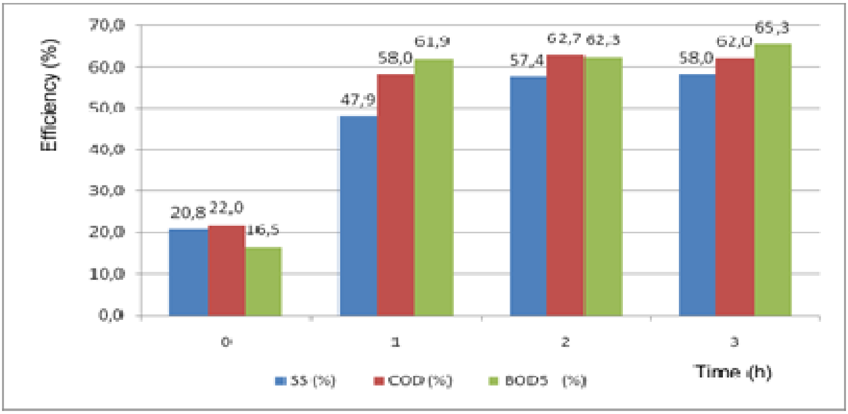


Figure 3.38: The diagram treatment efficiency of SS, COD, BOD5 (v = 12.5m/h)

With the velocity of 12.5 m/h, the post-treatment water did not meet A column value of QCVN 40:2011/BTNMT right from the first filter hours. This does not occur with the velocity of 5m/h, 7.5m/h and 10m/h respectively.

3.3.5. Test results to define the filtration intensity

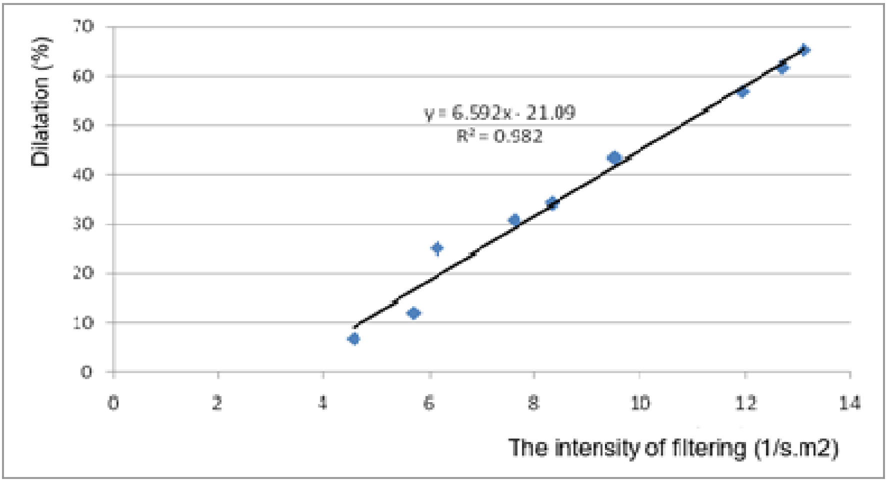


Figure 3.40: The diagram of the relationship between filtration intensity and expansion

The experimental formula to define the filtration intensity:

$$q = \frac{E + 21.09}{6.592} \qquad (3.1)$$

3.4. Discussion of the completed domestic wastewater treatment with self-cleaning floating polystyrene filters

Study results pointed out that the treatment efficiency of SS for the completed treatment to get mean values of 58.1%; 53.32% and

47.75% with the velocity of 5m/h; 7.5m/h and 10m/h respectively, gradually reduces when the filtration velocity increases.

Removal of organic substances (based on BOD_5) and ammonium NH_4^+ is highly effective; the average fluctuation of BOD_5 is between 44.85% and 64.4%, corresponding to the velocity of 10m/h and 5m/h; the average fluctuation of NH_4^+ is between 40.75% and 73.6% corresponding to the velocity of 10m/h and 5 m/h; It can be explained with the operation of biological films adhering to the developing surface of floating polystyrene and SS layer or micro-organism system drifted out from the second order aerotank and retained inside filter material.

It can be seen that total Nitrogen in treated water reduces, in average, ranging from 17.3% (v=10m/h) to 45.5% (v=5m/h). It means that other Nitrogen removal processes such as denitrification, must occur even if the dissolved oxygen concentration remains highly (DO=4-5mg/l). This can only be explained with the capacity of biological films, the structure of which includes anaerobic, air shortage and aerobic. The greater the amount of adhesive biological film is, the better the nitrogen removal efficiency is. In several conditions, based on some studies, anammox film can appear clearly in the depth of adhesive biological film. Because the thesis framework is applied study without any survey of micro-organism strains, thus, future studies should add micro-organism surveys.

The concentration of P in the treated wastewater decreased, proving that there is the growth in biological treatment process (phosphorus accumulation) in spite of the low treatment efficiency. It can be explained that because the organic concentration in the post-treatment water is diluted, the growth rate is not high, causing the P treatment efficiency low.

3.5. Define technological parameters of the SS filtration process

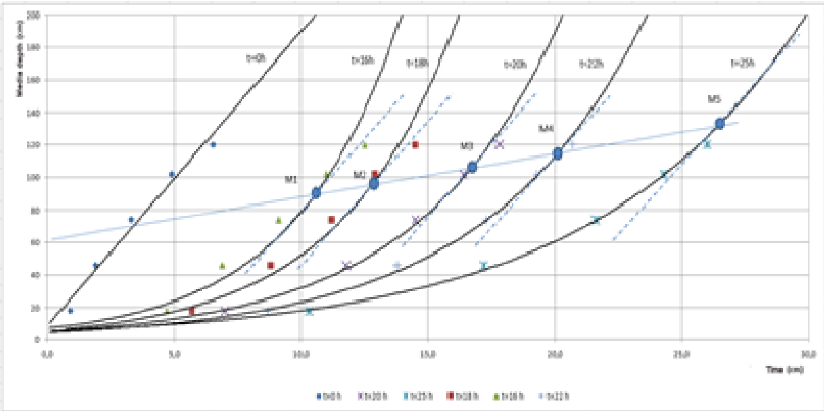


Figure 3.41: The relationship diagram between filter material thickness and head pressure loss with time (v =7.5 m/h)

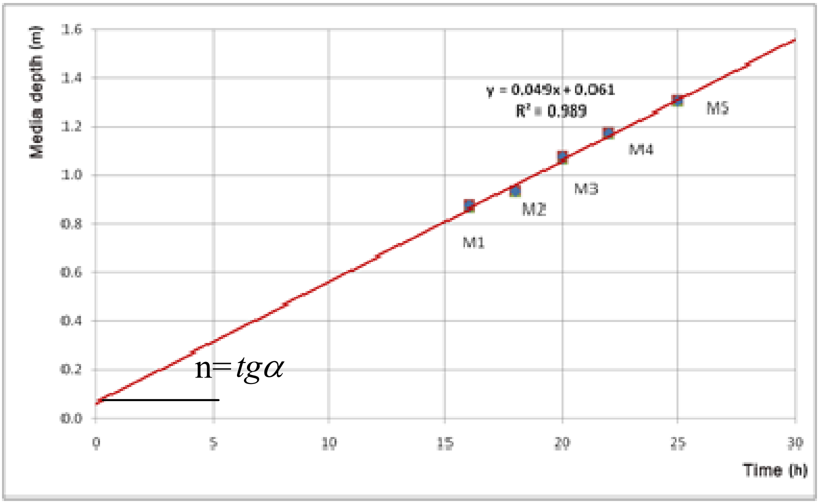


Figure 3.42: The relationship diagram between filter material thickness and the filter time (v =7.5 m/h)

Identify filter parameters including a and b described in section 2.4.3 of chapter 2. Through experimental results, filter parameters are found with the velocity of 7.5m/h, intensity of residue removal (a) and adhesion intensity (b) as follows: a = 0.562, b = 11.48; then from formulas in Figure 2.12 and 2.13, determining a = 0.375; b = 15.242 with the filtration velocity of 5 m/h; a = 0.75; b = 9.382 with the filtration velocity of 10 m/h.

3.6. Determine kinematic parameters of the removal process of dissolved organic substances (BOD, COD), dissolved inorganic substances (Ammonium, total nitrogen).

Based on experimental results and the method metioned in section 2.5.5, identify diagrams in Figure 3.43; 3.44; 3.45 and 3.46, from which, determine the reaction rate constant k_{COD} = 0.075; k_{BOD5} = 0.080; k_{NH4+} = 0.082; $k_{total\ Nitrogen}$ = 0.042

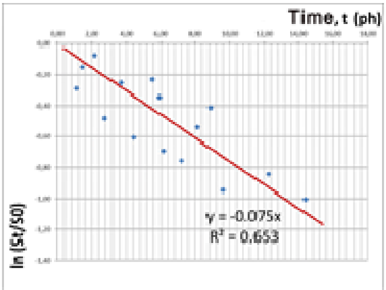


Figure 3.43. Determine the constant k_{COD}

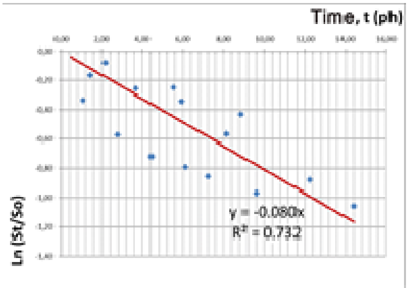


Figure 3.44. Determine the constant k_{BOD5}

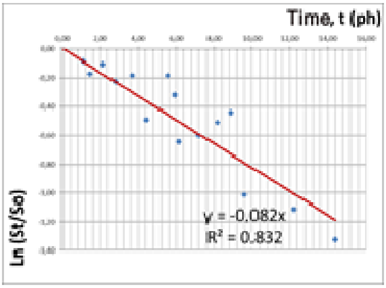


Figure 3.45. Determine the constant k_{NH4^+}

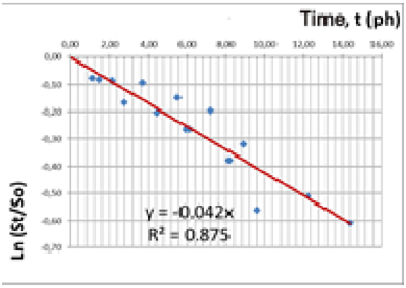


Figure 3.46. Determine the constant $k_{total\ Nitrogen}$

3.7. Develop the calculation method of self-cleaning floating material filters for the completed domestic wastewater treatment

Step 1: Define the reaction time of COD, BOD_5, NH_4^+ and total Nitrogen.
Step 2: Create the matrix to define the filter material thickness
Step 3: Identify the protection time (T_{bv})
Step 4: Define the siphon height of filters
Step 5: Create the matrix of technological parameters based on BOD5, NH_4^+-N, total Nitrogen and SS
Step 6: Determine the diameter of self-cleaning floating material filter
Step 7: Calculate the diameter of filter siphon
Step 8: Define the filter height
Step 9: Define the air volume to be supplied

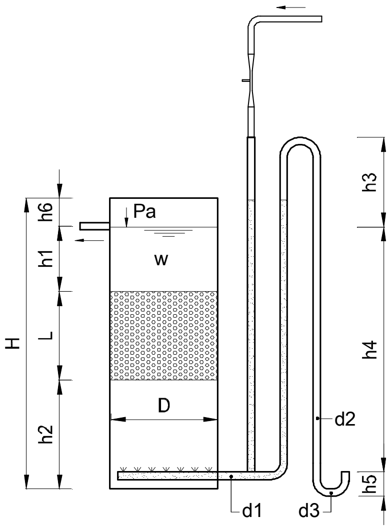


Figure 3.47: The calculation diagram of self-cleaning floating material filter

3.8. Practical application of self-cleaning floating material filters for completed domestic wastewater treatment into the treatment plant with capacity of 150 m^3/day&night

3.8.1. Location, size and properties of the applied treatment plant

The domestic wastewater treatment plant with the capacity of 150 m3/day&night has been applied in Dan Phuong district, Hanoi.

3.8.2. The applied wastewater treatment plant

The second order biological treatment works is an aerotank. Wastewater, before going to the filter, reaches B column and A column after the treatment in compliance with QCVN 14: 2018/BTNMT.

Based on the calculation of self-cleaning floating material filter with steps mentioned in section 3.7, there are 02 filters, the diameter of which is 0.9m; the thickness is 1.4m and the overall height is 4m.

Figure 3.50: Image of the applied self-cleaning floating material filters

The filter velocity is 5m/h and the filter cycle is 43h-47.5h. It can be found that post-treatment parameters are smaller than values in A column of QCVN 14:2008/BTNMT.

The filter results demonstrate the great applicability of self-cleaning floating material filters for the completed domestic wastewater treatment technology and prove their adaptability and working stability. It can prove the accuracy of design parameters studied by the thesis.

3.8.3. Economic and technical assessment on self-cleaning floating material filters

Self-cleaning floating material filters have shown good results. The investment rate accounting for 90% and the operational cost accounting for 56% of the costs mentioned in the Decision No. 451/QĐ-BXD. In addition, the land use area of the treatment plant is very small.

CONCLUSION AND RECOMMENDATIONS

Conclusion:

1. The thesis has provided an overview of urgent issues in Vietnam and all over the world for the completed domestic wastewater treatment and study results, structures, patents and applications of self-cleaning floating material filters.
2. The thesis has created a theoretical bases and conducted experiments on the completed domestic wastewater treatment with self-cleaning floating material filters at simultaneous removal mechanism based on: (1) the amount of suspended substances (SS) and organic compounds; (2) the amount of suspended substances (SS), organic compounds and nutrients.
3. Experiments have proved the completed domestic wastewater treatment efficiency based on SS, BOD_5, COD, $NH4^+$, total nitrogen in through polystyrene is (i) 58,10%; 64,40%; 66,90%; 73,60%; 45,50% with the rate of 5m/h; (ii) 53,32%; 60,67%; 61,48%;

66,02%; 43,03% with 7.5 m/h; (iii) 47.75%; 44.85%; 40.75%; 40.75%; 17.30% with the rate of 10m/h respectively;

4. Through several experiments, finding out kinematic relationship of technological parameters of the self-cleaning floating material filters working in the completed mode such as (i) increasing losses over time; (ii) SS contaminant concentration, organic components concentration according to BOD, COD; concentration of nutrients (NH4+, total N);

5. Experiments have found that filtration parameters to determine the intensity of sediment (a) and the residue adhesion strength (b) as follows: a = 0.375; b = 15.242 with the filtration rate at 5m/h; a = 0.562, b = 11.48 with the rate of 7.5 m/h; a = 0.75, b = 9.382 and the rate of 10 m/h;

6. Experiments have found that the constant reaction rate with the removal of organic substances according to BOD_5, COD, nutrients according to $NH4^+$, total nitrogen as follows: $k_{BOD} = 0.08$; $k_{COD} = 0.075$; $k_{NH4+} = 0.082$; and $k_{total\ N} = 0.042$;

7. Theoretical and experimental study results enable us to make a mathematical model describing the process of the third order domestic wastewater treatment with self-cleaning floating material filters;

8. Theoretical and experimental study results enable a calculation method for the design of the third order project for the completed domestic wastewater treatment on the basis of optimizing the filtration rate, protection time, siphon height, filter material thickness for simultaneous removal modes according to: (1) the concentration of SS and the organic substances (BOD_5, COD); (2) the

concentration of SS and the organic substances (BOD 5 , COD), the nutrients (NH_4^+ , total nitrogen).

9. The results have been applied in a treatment plant with the capacity of 150 m^3/day&night; and confirm the applied calculation process.

Recommendations

1. The self-cleaning floating material filter for completed wastewater treatment combines the mechanical SS filtration and biological removal of BOD and nitrogen. It can be used to upgrade the current or future wastewater treatment plant to satisfy the increasingly higher wastewater discharge standards or for the reuse and the circulation of wastewater. Make a proposal to apply the floating filters in general and self-cleaning floating material filters in particular into Vietnamese design specifications.
2. The next study orientation is combination of self-cleaning floating material filters and filtration film technology into one biological treatment process.
3. The next study orientation is combination of self-cleaning floating material filters and the MBBR carrier into one self-cleaning filter powered by water.
4. On the existing mathematical foundation, continue to create a floating filter calculation and design software for advanced wastewater treatment.
5. Widely studied and applied in the future with 2 recommendations about integrated biological reactors – self-cleaning floating material filters fully powered by hydraulic principles for treating organic-polluted water resources and ammonium pollution in domestic water treatment process.

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