MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF CONSTRUCTION

HANOI ARCHITECTURAL UNIVERSITY

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RESEARCH ON ODM-2F FILTER MEDIUM FOR SUSPENDED SOLID REMOVAL BY WASTEWATER ADVANCED TREATMENT TO REUSE IN URBAN

SPECIALITY: INFRASTRUCTURE ENGINEERING

CODE: 62.58.02.10

PDH TH

HA NOI 2022

The dissertation has been completed at Hanoi Architectural University

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This dissertation will be presented before the Doctoral Examining Board at Hanoi Architectural University

At: date ……month…… 2022

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INTRODUCTION

1. The necessity of the theme

Urban population is growing rapidly, operating industrial parks, hospitals and medical centers are generating a lot of waste and wastewater. Most of them are not being treated to satisfy the discharge requirements that have caused urban environment pollution and overloaded the receiving sources.

Domestic wastewater is identified as a resource and is always available in urban, if it is properly treated but only for discharge purpose, that will become waste and even makes environmental pollution worsen, whilst it can be recycled to reuse for a variety of purposes such tree, road watering.

Advanced treatment of urban domestic wastewater for reusing of tree, road watering purposes can be used in combination with biofiltration technology to remove organic matter and nutrients (for example MBBR technology) with the filter technology for suspended solids removal (for example the ODM-2F filter technology). In the Vietnamese market, there are a lot of filter materials produced domestically and import from abroad with grain structures, technical features suitable for water treatment and wastewater. The ODM - 2F material is such a type, originating from Russia, with the properties of an absorbing ability and is a dynamic filter material with basic chemical composition including: SiO_2 <= 84%; e_2O_3 <= 3,2%; Al_2O_3 + MgO + CaO = 8%; Grain Size 0,8-1,3mm; absorption capacity 1,3g/g and many other features as well as possible applications such as:

- Reducing Suspended Solids and organic compounds removal
- Combining many process facilities such as flocculation, Solids Removal in one equipment.
- It is possible to replace filter media without changing the filter tank structure.

The amount of back washing water is lower than that of other materials. No need to supply compressed air, save electricity etc…

From the above reasons, the author raises the need to carry out the thesis with the topic: "*Research on ODM-2F Filter Medium for Suspended Solid Removal by Wastewater Advanced Treatment to Reuse in Urban"* with the desire to select

wastewater advanced treatment process and determine parameters/ criteria to establish a suitable calculation method for the ODM-2F Filter facilities.

2. Objectives of the Study

- Studying and evaluating the current situation of wastewater reuse, establishing the theoretical basis and selecting wastewater treatment technology.

- Experimental research to determine parameters / criteria to establish calculation method for the ODM-2F filter.

- Research and applying mathematic calculation method into the design of ODM-2F filter facilities in advanced treatment of domestic wastewater to reuse for supplying recycled wastewater such as Fire Protection, tree and road watering for urban areas.

3. Subjects and Scope of the Study

a) Subjects of the Study: Domestic Wastewater from Plant

b) Scope of the Study:

- The Science:

+ Selection of wastewater advanced treatment process for (additional treatment of organic matter, nutrients and suspended solid remaining after secondary treatment)

+ Establish parameters / indices of suspended solid removal process on the ODM-2F filter model in advanced treatment of wastewater in laboratory and pilot conditions at site.

- The Scope: Domestic Wastewater.

- The Time: up to 2030, in the vision of 2050.

4. Contents of the Study:

- Overview Research on: (1) Advanced wastewater treatment and practical applications of ODM-2F Filter Tank; (2) Domestic wastewater Reuse for Fire Protection, tree and road watering Applications in Urban.

- Establish basis on: (1) Organic Substances, Suspended Solid, Nutrient Removal Theory; (2) Principles and criteria for selecting a domestic wastewater advanced treatment process; (3) Determine parameters / process indices of ODM-2F.

- Selection of advanced wastewater treatment process and system for reuse applications such as fire protection, tree and road watering.

- Experimental study on the ODM-2F Filter Tank Pilot.

- Develop a method to calculate the ODM-2F Filter Tank from experimental research data.

- Apply research results for a specific urban.

- Economic and technical assessment of wastewater treatment and reuse plan for supplying recycled wastewater for Fire Protection, tree and road watering.

5. Study Methods

- Methods of survey to collect data

- Data synthesis, analysis and evaluation method.

- The method of selective inheritance of former research results.

- Theoretical research method.

- Modeling method for experimental research.

- Wastewater quality analysis method with modern equipment.

- Methods of data processing and comparison of experimental results.

- Applied research method.

- Expert Seminor method.

6. Scientific and practical meaning of the thesis

- By reviewing the current situation, theoretical and practical basis of wastewater treatment and reuse and practical research on the ODM-2F filter pilot, the thesis has established the dependent relationships between process parameters and water quality criteria. Since then, a method of calculating the ODM-2F filter facility in the advanced wastewater treatment stage has been established in order to supply recycled wastewater for the Fire Protection, Tree and Road watering Applications in urban areas. The results obtained can be used for scientific research and specialized training in urban infrastructure engineering.

- The calculation method is applicable to the design and operation of the ODM-2F filter facility in the advanced wastewater treatment.

- The Reuse wastewater Solution for Fire Protection, Tree and Road Watering in Urban Areas brings economic, social and environmental benefits, as well as ensure the stable and sustainable urban development.

7. Results and Novelty of the Study

- Selecting a wastewater treatment process with the combination of organic matter and nutrient removal by MBBR and the process to remove suspended solid and dissolved sustances by ODM-2F filter medium to ensure water quality for for reuse of Fire Protection,Tree and Road Watering in urban areas

- Experimental research results demonstrate the excellent suspended solid removal ability of the Dynamic medium and from those results, a calculation method for the ODM-2F filter facility in the wastewater advanced treatment has been established for reuse of Fire Protection, Tree and Road Watering in urban areas. Calculation method for ODM-2F filter facility including 5 steps:

+ Determine the need for recycled wastewater according to the formula established in the thesis: $Q_{cnđt(III,tsd)} = 0,6125q_oN$ (for urban centers of grade III or higher) and $Q_{cnđt(IV,tsd)}=0,54q_oN$ (urban areas of grades IV and V)

(Note: q_o-Supplying water volume, l/person/day; N – Population, people);

+ Select filter cycle time according to the graph in Figure 4.3 which was established in the thesis, then determine the filter thickness by theoretical formulas;

+ Determine the filter area;

+ Determine the number of filter tanks;

+ Check the enhanced filter velocity;

+ Calculation of filtration and distribution systems.

- Economic and technical calculations show that the solution of treating and reusing wastewater for the purpose of Fire Protection, Tree and Road Watering in urban areas is completely applicable and brings economic, social, social and environmental benefits

CHAPTER 1. OVERVIEW OF WASTEWATER ADVANCED TREATMENT, RECYCLING SOLUTIONS AND RELATED RESEARCHS

1.1.1 Purpose of Advanced Wastewater Treatment

1/. Wastewater Treatment Level

Based on the Process Diagram, the efluent quality of the wastewater treatment plant, the level of wastewater treatment can be given as: Preliminary, Primary, Advanced primary, Sencondary, Tertiary and Advanced.

2/. The concept of advanced treatment of wastewater.

The combination of Tertiary wastewater treatment and higher is used and understood in the thesis is advanced treatment of wastewater for reuse.

3/ Objectives of Advanced Wastewater Treatment.

The purpose of advanced wastewater treatment is associated with the purpose of reuse: In urban areas, in industry, in agriculture and in groundwater recharge, etc.

1.1.2 Urban domestic wastewater treatment plants are operating in Vietnam.

Up to now, Vietnam has only about ~ 30 urban wastewater collecting sewer pipeline and treatment systems that have been constructed and put into operation with a design capacity of 769,000 m3/day and a working capacity of 558 630 m3/day, accounting for about 12% of domestic wastewater (according to the designed capacity) and 9.5% (according to the actual operating capacity) of the urban centers..

By 2020, Vietnam had about 60 centralized wastewater treatment plants that invested and put into operation with a designed wastewater capacity of 1435,000 m3 / day, 94% of the people can access to sanitation facilities, of which 90% of households use septic tanks as treatment facilities, and 60% of households connected to discharge combine wastewater collect sewer line.

Thus, the majority of urban areas in Vietnam do not have centralized wastewater treatment plants/ stations, especially small and medium cities have almost no drainage and wastewater treatment projects.

1.1.3 Water filtration works are used in practice.

1/. Filtration technology in water treatment and wastewater treatment and application.

According to Metcalt & Eddy, Inc. (2003), there are quite a few different types of water-heavier granular filtration tanks used to water and wastewater as well as advanced wastewater treatment. It can be named: (1) Water gravity filter tank moving forward or backward has one or more layers, automatic filter by pressure; (2) Single or multi-layer pressurized filter tank, automatic filter by pressure.

According to Le Van Cat and Trinh Xuan Duc, (2014), floating filter material filter tanks are: FPZ-1,2,3,4,5, FPZ4-N, AFPZ-5M, FPZ-COMPACT-2, FPZ. -COMPACT-10, the filtration can be operated by pressure.

1.1.4. MBBR technology and its applicability in advanced wastewater treatment.

1/. MBBR technology:

MBBR system has 2 types: aerobic MBBR and anaerobic MBBR ensure the performance of nitrogen treatment..

Design parameters are as follows:

Design parameters	Unit	Standard
The retention time in Anoxic tank	H	1,0-1,2
The retention time in Oxic tank	H	3,5-4,5
Surface area of the biofilm layer	m^2/m^3	200-250
Loading Rate of BOD	$Kg/m^3.day$	1,0-1,4

MBBR technology has advantages over traditional technologies for organic and nutritional treatment. Thus, MBBR technology is completely applicable to remove organic matter and nutrients in the advanced treatment process of wastewater for reuse of supplying water for Fire Protection, Tree and Road Watering in urban areas.

1.1.5 ODM-2F filter tank and application.

The above types of filter tanks can be used in advanced wastewater treatment to remove suspended solids remaining after tertiary treatment. However, the Dynamic ODM-2F material can replace both of sand, contact particles and activated carbon in water treatment, wastewater treatment and wastewater enhancement. Therefore, the author of the thesis plans to select an ODM-2F filter tank to remove suspended solids to ensure water quality for reuse of supplying water for Fire Protection, Tree and Road Watering in urban areas.

a) *Overseas Applications:* the Dynamic filter material ODM-2F has been applied for water treatment and wastewater treatment since 1998 in many water treatment projects in Russia, Ukraine, Uzbekistan (in Moscow, Perma, Yekaterinburg, Irkustsk, Omsk cities. ...) and in many other countries

b) *Domestic Applications:* In Vietnam, the ODM-2F filter tank has been used since 2002, mainly used for water treatmen: Diamond Plaza water supply system

(groundwater treatment); water supply system for milk production of Dutch Lady VN Company, Binh Duong Milk Factory; Tay Bac - Cu Chi Industrial Park water supply system; many water treatment plants supply to residential areas in the Central Highlands such as Dak Lak, Dak Nong, Cong Tum, Lam Dong ...) and provinces of Kien Giang, Soc Trang, An Giang, Binh Dinh, ...

1.2 Overview of Water Reuse.

1.2.1 Diagram of advanced wastewater treatment process to meet reuse requirements.

From the research results of many authors on wastewater treatment and reuse, it is possible to give an overall diagram of advanced treatment of wastewater for reuse purposes such as in figure 1.1.

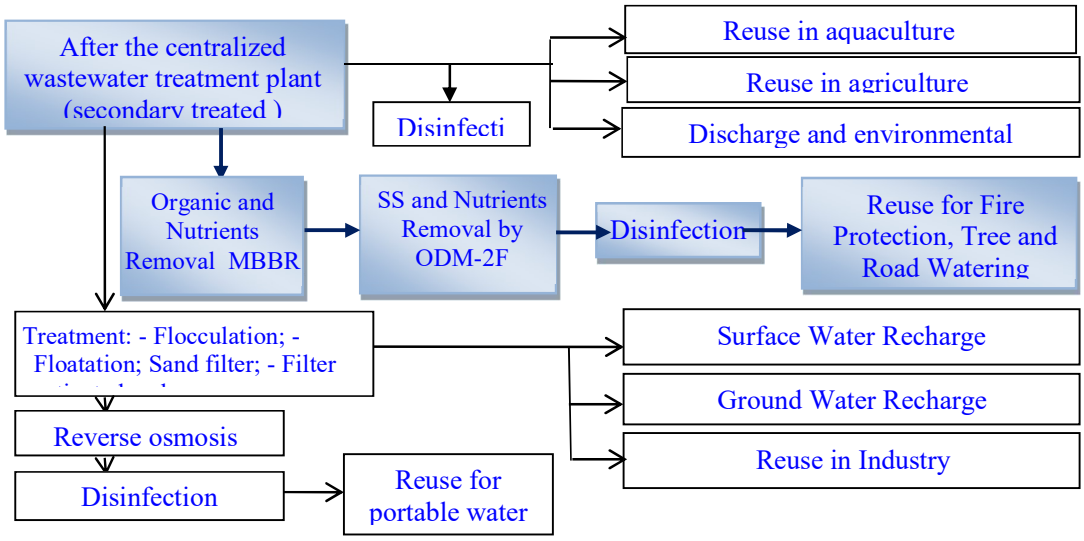


Figure 1.1. Overall diagram of treatment according to wastewater reuse requirements.

1.2.2 Overview of wastewater reuse in some countries around the world

The overview of reusing wastewater in some countries around the world, including the countries in the Mediterranean region such as Israel, Tunisia, Cyprus, Jordan…; European countries such as Austria, Belgium, France, Greece, Italy, Norway, Luxembuourg, Portugal, Sweden, the Netherlands and England ...; some countries in America, Latin America such as America, Brazil, Mexico ...; Asian countries such as China, Japan, Singapore, Thailand…; And Australia.

1.2.3 Overview of wastewater reuse in Vietnam.

In Vietnam, there are also many projects and studies on treatment to reuse wastewater in agriculture such as wastewater treatment and reuse plant in Lim town - Bac Ninh or new rural areas (NTM)

1.2.4. Reviews of wastewater treatment and reuse

According to data, the amount of recycled water in countries around the world tends to increase. For example: in Israel, Australia and Tunisia the amount of recycled water is 25%, 11% and 10% of the total water demand, respectively. In Egypt is expected to increase to 10 times by 2029.

In Vietnam, there have been research projects on applying wastewater treatment and reuse for aquaculture and agricultural irrigation such as in Lim town, Bac Ninh and in rural areas that have just achieved effective productivity harvested amount, while still ensure the environment protection.

1.3 Related research.

Domestic and international studies focus mainly on issues such as: Treatment to reuse wastewater in agriculture, aquaculture, industry.

However, the advanced treatment of wastewater to use for Fire Protection, Tree and Road Watering in urban areas in our country just applied to research with a small scale of works. There are no full research on urban scale.

1.4 Issues that need to study and solve in the thesis

From the overview of advanced wastewater treatment and reuse as well as the application of the ODM-2F filtration technology, we can make the contents and problems that need to be further resolved in the thesis, which is:

- Basis for process selection and determination of process parameters as well as water quality criteria for reuse for Fire Protection, Tree and Road Watering in urban areas.
- Experimental ODM-2F Filter Tank.
- Determine demand for recycle water in urban areas.
- Develop a calculation method for ODM-2F filtration technology in advanced wastewater treatment.
- Apply research results to specific urban areas.

CHAPTER 2. SCIENTIFIC BASIS OF TREATMENT TECHNOLOGY SELECTION AND ADVANCED WASTEWATER TREATMENT THEORY FOR RESUE IN URBAN

2.1. Wastewater Quality.

2.1.1 Wastewater Quality before Advanced Treatment.

The wastewater quality before advanced treatment meets collumn A of QCVN 14: 2008 / BTNMT. As follows: pH = 6-7; $BOD_5 \leq 30$ mg/l; Total Dissolved Solids ≤ 500 mg/l; SS ≤ 50 mg/l; Kjeldahl Nitrogen TKN ≤ 5 mg/l; Phosphorus ≤ 5 mg/l.

2.1.2 Wastewater Quality after Advanced Treatment.

The quality of reused water for fire protection, tree and road watering purposes is generally recommended as follows: pH= 6-9, Colour ≤ 30, Turbidity ≤ 5, Total Dissolved Solids ≤ 1000 mg/l, BOD_5 ≤ 10 mg/l, SS ≤ 10 mg/l, NH_4-N ≤ 3 mg/l, Phosphorus $PO_4 \leq 2$mg/l.

2.2 Principles, criteria and procedures for selecting advanced wastewater treatment technology

Given principles and 3 criteria for evaluating the sustainability of wastewater treatment projects (technical, environmental, social and economic), 06 groups of criteria for selecting wastewater treatment processing technologies (efficiency wastewater treatment, economy, technological level, suitability to local conditions, adaptation to climate change and safety and environment friendliness) and a two-step procedure of selecting advanced treatment technology.

Offering two steps for the processing technology selection, including: (1) Preliminary selection to determine the suitability of treatment process; and (2) The final choice usually conducts the matrix of process selection and select the appropriate process.

2.3 Theoretical basis for organic substance, nutrient and suspended solids removal

2.3.1 The theory of organic substances and nutrient removal.

1/. BOD removal

BOD removal of wastewater often uses the activity and growth of aerobic and anaerobic microorganisms with two methods using microorganisms activity in suspended and adhesion condition.

2/. Phosphorus removal

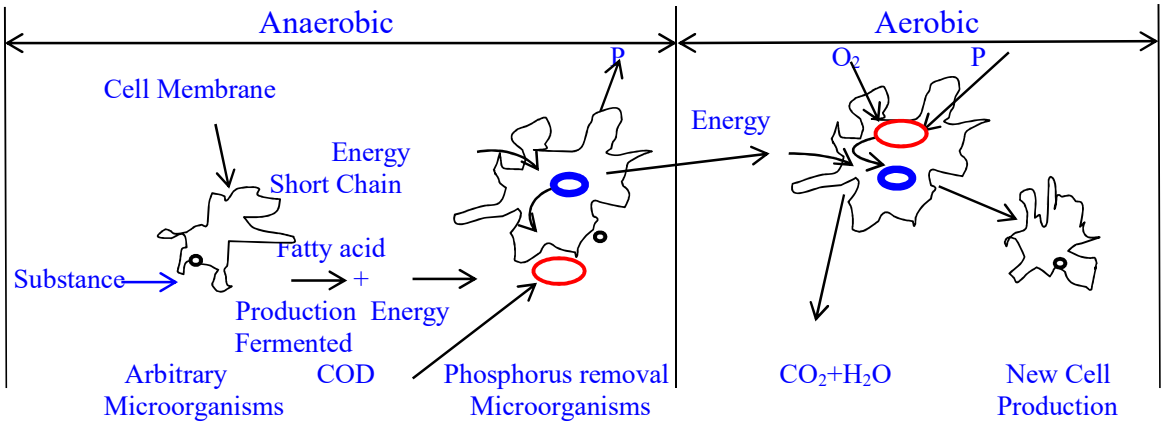


Figure 2.1: Mechanism of removing excess phosphorus (COD – Chemical oxygen demand,

PHB – poly-β-hydroxybutyrate) (Bowker and Stensel, 1987); - PHB; - Carbon Resource

3/. Nitrogen Removal

Nitrogen removal is a two-stage process of nitrification in an aerobic reactor followed by denitrification in an anoxic reactor.

Nitrification follows two steps: $NH_4^+ + 1,5O_2 \rightarrow NO_2^- + 2H^+ + H_2O$ và $NO_2^- + 0,5O_2 \rightarrow NO_3^-$

The reactions remove nitrate and form nitrogen gas: $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

2.3.2. A number of advanced wastewater treatment technologies to remove organic substances and nutrients

Introduction of organic and nutrient processing technology diagrams such as: modified Bardenpho, AAO technology, UCT technology (University of Cape Town), Phostrip II technology, adhesive biofilter technology - activated sludge (FGR - SGR), C-tech technology, MBR technology and MBBR technology.

2.3.3 Water filter material, ODM-2F dynamic medium and floating bio-attachable material:

1/. Water filter material: Normally they are activated carbon, quartz sand, PH lifting particles, ion exchange particles, porous particles, water filter gravel, filters ... These materials can help improve water sources, intense purify water . . At the same time, it helps to raise the pH, oxidize the water source before using.

2/. ODM-2F dynamic material: Can be used to replace both quartz sand, contact particles and activated carbon in water filtration and wastewater treatment technology. The main ingredients are diatomite, zeolite and bentomite with SiO2 ratio <= 84%; Fe2O3 <= 3.2%; Al2O3 + MgO + CaO = 8%.

3/. Floating bio-attachable material MBBR: The floating bio-attachable material has many forms such as: sphere, PE-04 wheel. Spherical type D50, D100 and D150 and filament (AFBR) ...

2.3.4 Theory of solids removal through the ODM-2F dynamic material

Presentation: (1) Principle of water filtration through ODM-2F dynamic material (2) Identify uniform numerical standards; (3) Determine the time and law of increasing hydraulic losses in the water purification process.

2.4 Theoretical basis for experimental research.

2.4.1 Similarity Theory Basis.

Studying the similarity theory basis to set up an practical pilot that reflect the physical properties of the ODM-2F filter tank such as: - Similarity in three geometrical dimensionless (length, area and volume); - Similarity in proportions of the relationship between kinetic processes (velocity, flow, headloss...) according to the differential equation of the similar number standard.

2.4.2 Scientific assumption for experimental research.

When the wastewater flows through the filter material, the suspended solids are kept in the space between the filter material particles by the sieve mechanism. This assumption allows to study the parameters of the filtration process such as filtration velocity, effective filtration time, filtration headloss and filter washing parameters.

2.5 Conclusion.

From the study of theoretical and practical bases, the project has:

- Selected the quality inlet and outlet of wastewater advanced treatment plant for reuse purposes such as watering tree, road and fire protection in urban areas.

- Selected the floating biological media for organic subtances and nutrients removal of biological treatment and ODM-2F filter material for suspended solids removal.

- Provided principles, criteria and procedures for selecting advanced wastewater treatment technologies.

- Built up the theoretical basis (1)Removal of organic substances and nutrients; (2)Removal of suspended solids by the granular filter media; and (3) Similarity theory apply to practical pilots.

CHAPTER 3. PROPOSE ADVANCED WASTEWATER TREATMENT TECHNOLOGY AND EXPERIMENTAL RESEARCH OF ODM-2F FILTER TANK

3.1 Propose advanced wastewater treatment technology to reuse for watering tree, road and fire protection purposes in urban areas.

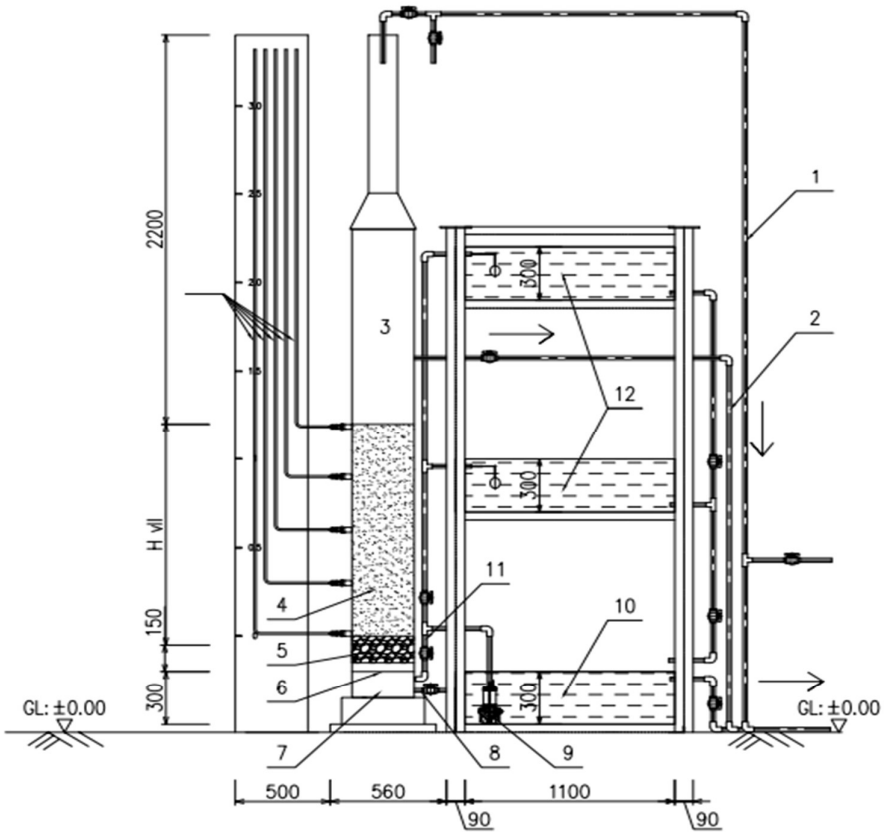
General Selection of wastewater treatment technologies, thereby assessing the advantages and disadvantages, the scope of application and implementing the process of technology assessment and selection..

The technologies including AAO, CAS, SBR, MBR and MBBR have been introduced and evaluated according to the criteria of economic efficiency, technological level, suitability to local conditions, and adaptation to climate change. safe and environmentally friendly and estimate scores for selection comparison.

The results have selected MBBR filter technology to remove organic matter and nutrients, ODM-2F filter technology to remove suspended and dissolved solids for advanced wastewater treatment to reuse.

3.2 Experimental Pilot

From the similar theory of geometry, the thesis has calculated the experimental pilot as shown in Figure 3.1



Hình 3.1: Sơ đồ mô hình thực nghiệm

1- Ống dẫn nước thải lên mô hình cột lọc, d15mm; 2- Ống xả nước rửa lọc, d25mm; 3- Cột lọc, D150mm ; 4- Vật liệu lọc (đa năng ODM-2F hoặc cát thạch anh); 5- Vật liệu đỡ, h = 150mm; 6- Đan đỡ vật liệu lọc; 7- Đáy thu đựng nước lọc và phân phối nước tửa lọc, h =150mm; 8- Ống dẫn nước sau lọc, d15mm; 9-Máy bơm rưa lọc.;10- Khay chứa sau lọc và đặt máy bơm rửa lọc; 11- Ống dẫn nước rửa lọc, d25mm; 12- Khay chứa nước rửa lọc ω_2 và ω_3.

3.3 Purpose, object, scope of research and experimental plan

3.3.1 Purpose, object and scope of the study:

a) Purpose: (1) In the laboratory: Comparison of the ability to remove suspended solids of ODM-2F material compared with quartz sand; (2) Practical Pilot: Determinate parameter/citeria of ODM-2F filtration process to develop a technological calculation method in advanced wastewater treatment to reuse for watering tree, road and fire protection purposes in urban areas.

b) Object of the Study: Treated Wastewater from Wastewater Treatment Plant.

c) Scope of the Study: Suspended Solids removal from advanced Wastewater Treament.

3.3.2 Experimental parameters/criteria and procedures

1/ Experimental parameters/criteria:

- Parameter: PH, suspended solids; organic compounds;

- Filter Parameter: Flowrate, Velocity, Filter time and Headloss, Backwash time and Backwash rate.

2/. Experimental procedure: - Prepare Pilot and experimental equipment; - Pump water into the Pilot and adjust the flowrate, velocity; Sampling to determine parameters/criteria.

3.3.3 Methods of analysis and determination of experimental parameters/criteria.

- The method of analysis for water sampling was carried out in compliance with current standards. The determination was carried out at Environmental Laboratory, Institute of Environmental Science, Hanoi University of Science and Technology.

- Method of determining the quantities and operating parameters of the pilot: - Parameters of water filtration (wastewater flow (m3/ngd); filtration velocity (m/h); filter headloss (m) and backwashing parameters were determined by measuring devices in the field).

3.3.4 Experimental planning.

The establishment of Pilots to determine the parameters proceeds in 5 steps: (1) Determining the factors affecting the solids separation process; (2) Determine the external relationship between the object and the influencing factors; (3) Determine the statistical description of the experimental pilot; (4) Define statistics; (5) Checking the coincidence of the description.

The results show that the pilot is compatible with the experimental planning, specifically:

- Inverse ratio and interaction between required flowrate, Hydraulic Load and Suspended Solids Retention Time

- Inverse ration and interation between Hydraulic Load, Suspended Solids Retention Time, Filter Diameter and Tank Height

- Inverse ration and Interaction of required flowrate.

3.3 ODM-2F filter experimental results

Conducted 03 experiments on ODM-2F filter pilot (the pilot is located at Kim Lien wastewater treatment plant), the results contain dependent graphs as below:

1/. Graph of SSt/SSo ratio and filter time.

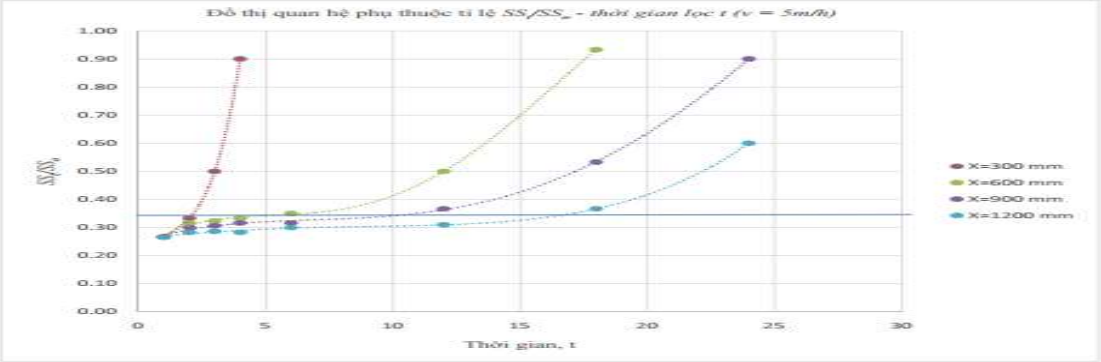


Figure 3.2. Graph of SS/SS_o and filter time t relation (V = 5mh)

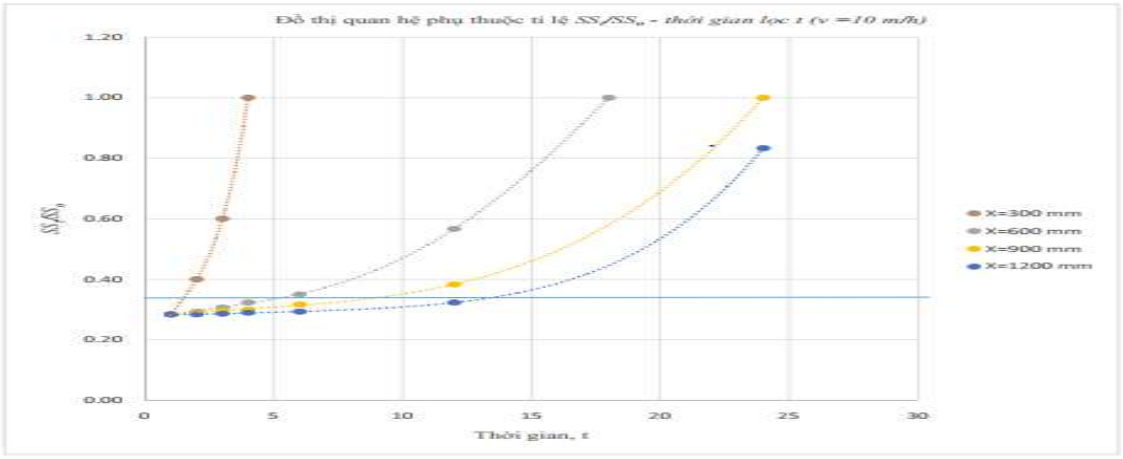


Figure 3.3. Graph of SS/SS_o and filter time t relation (V = 7,5m/h)

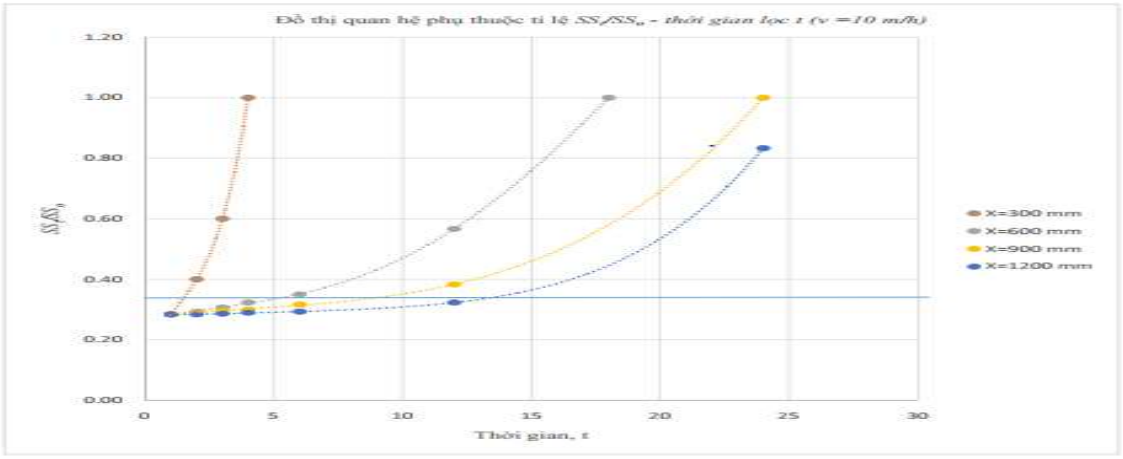


Figure 3.4. Graph of SS/SS_o and filter time t relation (V = 10m/h)

2/. Dependency graph SS – filter thickness x

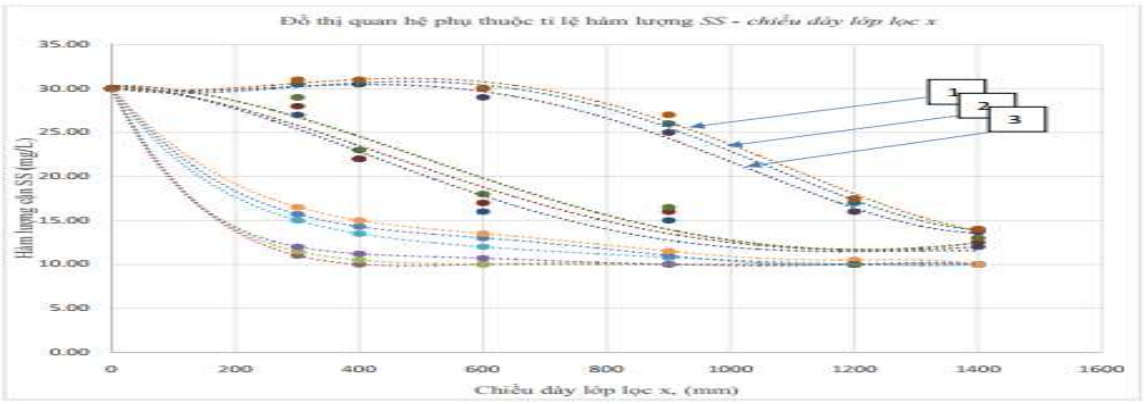


Figure 3.5. Graph of SS concentration and filter thickness x

Remark: I-Characteristics of early stages of filteration process; II,III,IV,V…Characteristic of the following stages

3/. Graph of SS – filter time t

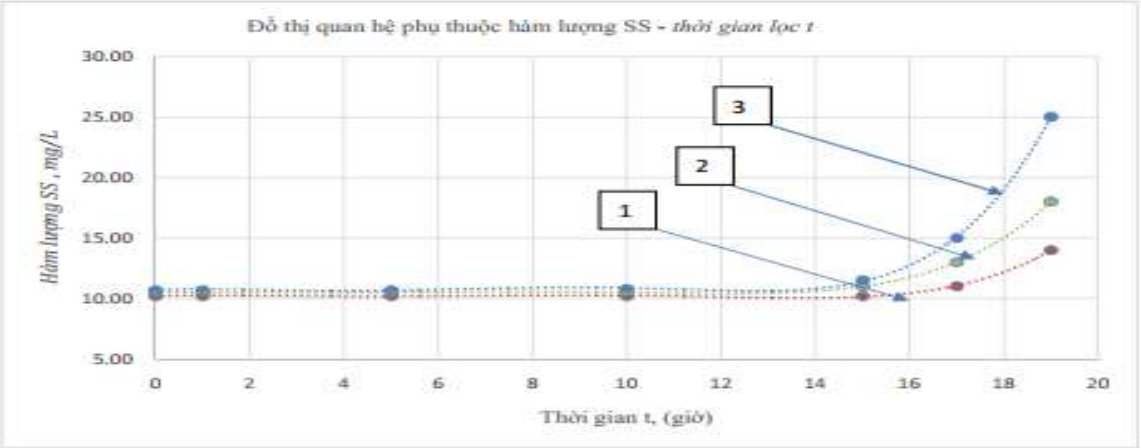
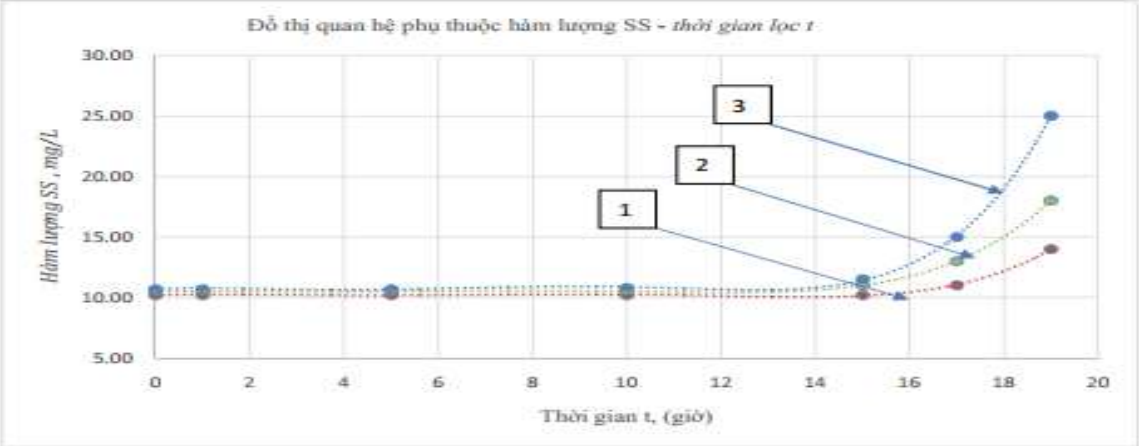


Figure 3.6. Graph of SS concentration – filter time t

(Remark: 1.Vecocity v= 5m/h; 2. Velocity v = 7,5m/h; 3. Velocity v = 10m/h)

3/. Process experimental results related to filter headloss and filtration time.



Hình 3.7. Graph of headloss h – filter time t

3.4 Conclusion.

1. The experimental pilot is built on the basis of the similar theory (1) on geometry: $\lambda_d = D_n/D_m = D_n/0,15$; $\lambda_H = H_n/H_m = 1$; (2) on kinematics: $\lambda_v = v_n/v_m = 1$ và $\lambda_j = J_n/J_m = 1$.

2. From the analysis and evaluation of groups of criteria for selection of treatment technology, the thesis has:

- Proposed organic and nutrient removal technology by MBBR technology and suspended solids removal technology by ODM-2F filter.

- Selected advanced wastewater treatment technology suitable for reuse purposes in urban areas, including: Tertiary Sedimentation Tank => MBBR Tank => ODM-2F filtration => disinfection.

3. Experimental study of ODM-2F filter with the aim of determining water quality criteria, filtration parameters (velocity, time, loss) and backwash (flowrate and time) were carried out according to the current standards and regulations. Experimental results show that the removal efficiency of SS and dissolved residues satisfied the required quality for reuse purposes in urban areas..

4. Filter Resule ODM-2F: $E_{ss(ODM-2F)}$ = 70%.

CHAPTER 4. ESTABLISHMENT OF ODM-2F FILTER CALCULATION METHODS AND APPLICATION

4.1 Establishment of ODM-2F Filter Calculation

4.1.1 Determine the filter and backwash parameters from experiment results.

- Determination of filter parameters on the basis of experimental research results with different filtration velocities. The results obtained are summarized in Table 4.1:

Bảng 4.1. Filter parameters with different filter velocities

No.	Filter Parameter	Velocity, v (m/h)		
		5	7,5	10
1	Filter Layer Thickness x (mm)	1700	1700	1700
2	Filter Particle Size (mm)	0,8-1,2	0,8-1,2	0,8-1,2
3	Filter parameter a	0,962	0,862	0,748
4	Filter Parameter b (m^{-1})	11,6	9,7	8,3
5	Ratio a/b (m/h)	0,083	0,086	0,0902
5	Ratio SS_t^{tb}/SS_o^{tb}	0,34	0,34	0,34
6	Constant X_o (Depends on filter efficiency)	1,1 6	1,16	1,06
7	Constant K (Depends on filter efficiency)	1,18	1,18	1,16
8	Unit Headloss, i_0	0,80	0,83	0,86
9	1-A	0,80	0,84	0,88
10	Optimal filter time t_{tu} (h)	16	15,5	15

From Table 4.1, it is possible to establish a sub-graph between the filtration velocity and the optimal time as shown in Figure 4.2 to use for the design calculation of the filter tank.

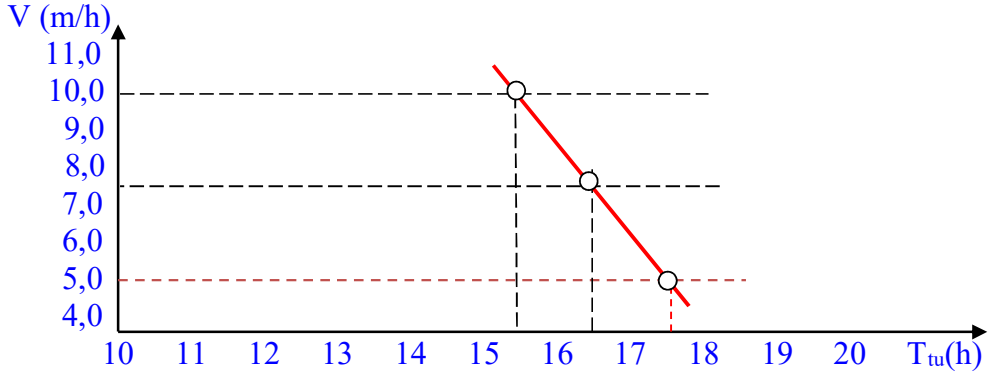


Figure 4.2. Dependency graph between filter thickness and optimal filtration time.

- The average backwashing parameters have been determined for general use for different filtration velocities (v=5÷10m/h) including: Backwashing rate qo =14l/sm2; Backwashing time t = 18 minutes; volume of washing water Wt (m3).

- In addition, it is also possible to calculate and determine the thickness of the solid layer covering the filter particles = 20µm.

4.1.2 Determining the demand for reused water in urban

From the data that listing the demand of water supply services in urban, a formula for calculating the demand for reused wastewater can be established as follows:

- For Urban grade III or higher: $Q_{cnđt(III,tsd)} = 0{,}6125 q_o N$ (4.1)

Where: q_o–Water Supply Rate (l/person/day); N–Amount of user (person).

- For Urban grade IV and V: $Q_{cnđt(IV,tsd)} = 0{,}54 q_o N$ (4.2).

4.2.3 ODM-2F filter tank design calculation procedure.

1/. Determining the demand for reused wastewater in urban.

Calculated according to formula 4.1 (for urban of grade III and above) and formula 4.2 (for urban of grades IV and V).

2/. Select filter cycle time and filter layer thickness:

Based on the chart in Figure 4.1, it is expected that the filter velocity V(m/h) ➔ select $T_{lọc} = T_{tr}$.

Determine the filter layer thickness according to the formula:

$$t_{gh} = \varphi \frac{H_{gh} - H_o}{H_o.F(A)}.\frac{b}{a}x = 1{,}36\frac{H_{gh} - i_o x}{i_o x.F(A)}.\frac{b}{a}.x \rightarrow x = \frac{H_{gh}}{i_o} = \frac{1}{1{,}36}.\frac{a}{b}.T_{Tu}F(A)$$

(Where: $\varphi = \left(\frac{d_{td}}{d_{20}}\right)^2 = 1{,}36$; $H_{gh} = 2m$; $H_o = i_o x$; $i_o = 0{,}8 \div 1{,}1$)

3/. Determine the filter area:

$F = Q/v\ m^2$ (Where: Q -Flowrate, m^3/h; v –Velocity, m/h).

4/. Determine the number of filter tanks:

$n = \frac{1}{2}\sqrt{F}$ (Where: F- area of filter tank, m^2)

5/. Enhanced filter velocity re-check:

$$v_{tc} = v\frac{N}{N-1} \leq 10\ m/h$$

6/. Calculation of filtration and Backwashing distribution systems:

Calculation of Water Distributing and Backwashing systems proceeds according to the method recommended in the current teaching materia.

4.4 Application of research results to wastewater treatment plan in Dan Phuong Phuong district, Hanoi.

4.4.1 Description of domestic wastewater treatment plant.

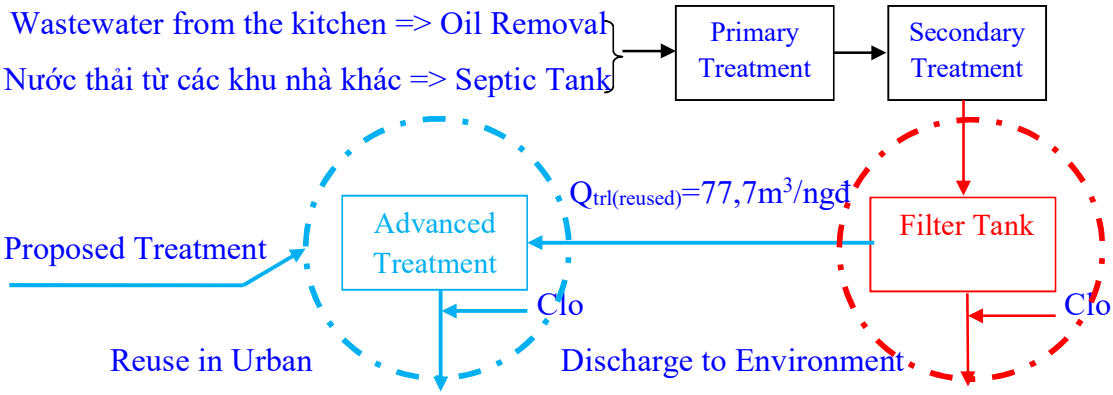


Figure 4.4: Dan Phuong Wastewater Treatment Process Diagram Q = 150 m^3/ngđ[9]

4.4.2 Proposing advanced wastewater treatment technology.

The Technolofy of advanced wastewater treatment for reuse is proposed as follows:

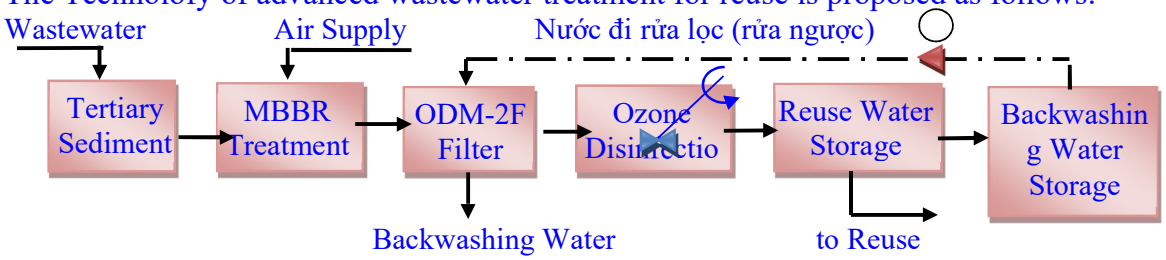


Figure 4.5. Diagram of advanced wastewater treatment technology (Q=7,82m^3/ngđ).

4.3.3 Calculation and design of works in the technology of advanced wastewater treatment in urban.

The calculation of works in the advanced processing technology has been carried out. In calculating ODM-2F filter technology, researcher has used the calculation method proposed in the thesis. The calculation results of the ODM-2F filter tank are as follows:

		Dimension, m	Backwashing Parameter

Q_{trl} (m^3/day)	Number of Tank	Diameter , D	Height							
			Support Layer, $H_{đơ}$	Filter Layer, H_1	Water Height H_2	Spare Space, H_2	Total Height, H_{xd},	T_r (phút)	q_r (l/sm^2)	W_r (m^3)
77,82	2	2	0,7	1,5	1,2	0,3	3,7	17	14	7,48

4.4 Evaluation of economic and environmental benefits, solutions to reuse wastewater.

Estimated Economic Factors for ODM-2F Filter Plant.

The economic and environmental benefits have been determined, the solution is to reuse recycled domestic wastewater in urbans.

4.5 Discussion.

Discussed about: (1) Reseach Results; (2) Volume demand and solutions to reuse wastewater in urban areas; (3) Application Possibility of ODM-2F filter tank calculation method.

GENERAL CONCLUSION AND RECOMMENDATIONS

Conclusion

1. Wastewater reuse is increasingly widely used not only in the fields of agriculture and industry but also in all areas of production and human life. Depending on the purpose of reuse, wastewater can be treated with different levels. Advanced wastewater treatment is a combination of tertiary treatment and advanced treatment to ensure water quality for reuse in urban areas.

2. By surveying and collecting actual management data, the thesis has proposed the quality of wastewater influent and effluent, calculated the level of advanced wastewater treatment, and from an overview study of the current state of industrial applications. water treatment technology as well as analyzing and evaluating groups of criteria for selecting treatment technology, the thesis has:

- Selected technology to remove organic and nutritional contaminants by MBBR

- Selected the technology to remove the remaining suspended solids after secondary treatment to create effective working conditions for MBBR technology and selected the remaining and formed solids removal technology in the advanced wastewater treatment stage by ODM-2F filter tank.

- Selected of advanced wastewater treatment technology suitable for reuse in urban areas, including: Tertiary sedimentation => MBBR => ODM-2F filtration => Disinfection.

3. From the theoretical basis, a filter pilot has been built and experimental research is carried out in the laboratory and in the field.

- Laboratory studies have determined that ODM-2F's suspended solids removing capacity (EODM-2F = 69 ÷ 70%, see PL6) is better than quartz sand's filtration capacity (Ecat = 6E68). %, see PL6)

- Research pilot in the field:

+ Dependency relationship between filter criteria/parameters such as the ratio of SS/SSo content

- filter time t; ratio of SS/SSo content - filter thickness x; SS content – filter thickness x; SS content – filtration time t; and filter headloss h – filter time t;

+ The relationship of filter parameters (filter thickness, filter cycle time, filter velocity) and filter backwashing parameters (filter washing volume, filter washing time...);

+ Calculation method of ODM-2F filter in advanced wastewater treatment for reuse in urban areas.

4. From analyzing, evaluating regulations on water supply standards and inheriting previous research results of domestic and foreign authors on wastewater reuse, the thesis has built a Formula for determining the need for reuse water in urban areas:

- For Special, I, II, III urban areas:

$Q_{cnđt(III,tsd)} = 0,6125q_oN$

- For IV, V urban areas:

$Q_{cnđt(IV,tsd)} = 0,54q_oN$

Where: q_o- water consumption standard, l/person/.ngđ;

N- polulation (person)

6. The thesis conducted research to apply the proposed calculation method to calculate and design the ODM-2F filter in the advanced treatment stage of wastewater to reuse for urban areas of the district. Dan Phuong (capacity Qtrl = 77.82 m3/day).

7. The treatment and reuse of wastewater for water supply purposes in urban areas can reduce the proportion of water extracted from natural resources by ~41.7% for urban centers of type III and above, and ~ 38.9% for cities of type IV and V. At the same time, the percentage of wastewater discharged into the receiving source can be reduced ~52.1% for cities of type III and above and ~ 50.7% for urban type IV and V, thereby better ensuring self-recovery ability and protecting the receiving source environment.

Recommendation

1. The research results of the thesis are applicable, but in order to be able to apply in practical solutions to treat and reuse wastewater, the government needs to have guidelines and policies to encourage the use of recycled wastewater, especially for Fire Protection, Tree and Road Watering. At the same time, it is necessary to conduct research on both the organization and management of the wastewater reuse system in accordance with the construction characteristics, socio-economic development conditions and the environment of urban residential areas in Vietnam.

2. In the thesis, it is not possible to research fully and in detail on a number of related issues such as: (1) the ability to link between process facilities of advanced wastewater treatment to ensure the the optimal efficiency; (2) Research on advanced wastewater treatment was carried out with the assumption that the quality of influent reached QCVN 14:2008/BTNMT. In other cases, it is necessary to have more urgent studies or design calculation in accordance with the quality of wastewater influent.

3. Need more Pilot studies for different urban areas to achive desired economic, social and environmental effects before apply to practical solutions.

4. At the same time, it is necessary to develop a strategy for the reuse of wastewater in accordance with the legal regulations and the socio-economic development stage of Vietnam Urbans

THE AUTHOR'S PUBLISHED SCIENCE ARTICLES RELATED TO THE THEISS

1. Hoàng Huệ Quân, 2017. *Wastewater treatment and reuse of non-drinking purposes is necessary for small and medium-sized cities in the Red River Delta*. Vietnam Journal of Construction – ISSN 0866-0762

2. Hoàng Huệ Quân, 2017. *Research on Wastewater treatment and reuse of non-drinking purposes in small and medium-sized cities in the Red River Delta.* Vietnam Journal of Construction – ISSN 0866-0762

3. Hoàng Huệ Quân, 2017. *Fundamentals of BOD, Nitrogen and Phosphorus treatment in Wastewater by AAO technology.* Vietnam Journal of Construction – ISSN 0866-0762

4. Nghiêm Vân Khanh, Hoàng Huệ Quân, 2019. *Results of experimental research and development of the calculation method for ODM-2F Filteration technology in advanced wastewater treatment for urban non-drinking water* . Science Journal of Architecture & Construction – ISSN 1859-350X