

Thesis defense process

Department of Environmental Engineering, Faculty of Engineering,
Chulalongkorn University



Requirements for graduation

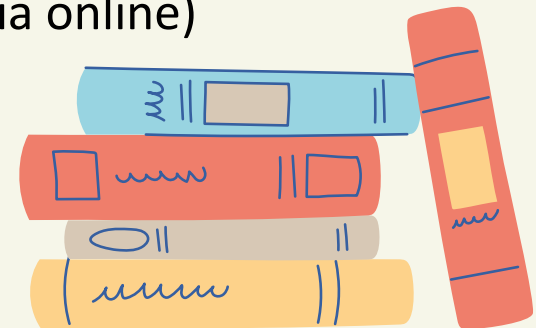
Master's Degree

- Coursework 24 credits (compulsory 18 electives 6)
- Thesis 12 credits
- CU-TEP score ≥ 45 (no course required)
CU-TEP score 30-37 : completed 2 courses
CU-TEP score 38-44 : completed 1 course
- Present at 1 conference (national level at least)

Ph.D.

- Number of credits depends on the program (contact aarn On-anong)
- CU-TEP score ≥ 67 (no course required)
CU-TEP score 45-60 : complete 2 courses
CU-TEP score 61-66 : complete 1 course
- Publish 2 journal papers

- The article submitted to the conference must be a full paper only
- **The submitted article must undergo a reviewer's comment**
- The presentation must be an **Oral presentation only** (can be via online)
(Poster presentation is not acceptable)
- The conference must have a conference proceeding
(can be a hard-copy print or an electronic file)



4 main steps

Submit the intent to defend your thesis



Defend thesis and revise as per committee's comments



Submit documents to The Graduate School and
The Faculty's Registrar



Clearing of research grant reimbursement
(everyone must do)



Submit the intent to defend your thesis

Prepare documents as follow

1. Thesis defense request form (Must be typed only, no hand-writing)

Thesis Defense Request form
Department of Environmental Engineering, Faculty of Engineering, Chulalongkorn University
 Master Program Ph.D. Program
 1st 2nd Semester, Academic Year 2021. Entry Number.....

To: Head of Environmental Engineering department, **Master**
I am **Bonita Pen**, a Ph.D. candidate in **2nd** year, student ID no. **6272049021**, tel. **0925808847**.
 I have completely registered courses in the programme in 2020 academic years with **42** credits, GPA **3.81**.
 I achieved CU-TEP score more than 45/100FL score not lower than 45/100 IELTS band not lower than 4.0/5.0 for English proficiency test.....
 Thesis proposal no. **17.7.2563** was approved not less than 60 days before the thesis defense date.
 Thesis has been uploaded to CU-LIS and already approved by the advisor.

I have presented my thesis in National/International academic conference for..... times, as follow:
Name of academic conference: **14th AUN/SEED-Net Regional Conference on Environmental Engineering 2021 (RCEnvE2021)**
Research Title: **Effect of Solid Media Addition on Mass Transfer and Bubble Dynamics in Bubble Column Reactor**
On (date of presentation) **7th October** at (place) **online** in (country) **Malaysia**

Name of academic conference.....
Research Title.....
On (date of presentation)..... at (place)..... in (country).....

paper(s)/ article(s) has/ have been published in National/ International Journals, as follow:
Article Title.....
Name of journal..... Year..... Volume..... page.....
Article Title.....
Name of journal..... Year..... Volume..... page.....

Thesis title **Removal of ferrous and arsenic from contaminated groundwater by co-precipitation coupling with membrane separation process**

Committee members
Asst. Prof. Manasorn Rachakornkit, PhD Chairman/ External committee
Prof. Pisut Paimanukul, PhD Advisor
Dr. Pattarasri Engkaew Co-advisor (if any)
..... Committee
Asst. Prof. Manupatch Jannongroong, PhD Committee
Assoc. Prof. Khemarath Osathaporn, PhD Committee
..... Committee

- The objective(s) in the thesis proposal and the thesis draft issue changed? unchanged. (Any changes, please fill the form no. 2.2)
- The research procedures have completely been followed. (Any changes, please fill the form no. 2.2) **Advisor's comments**

I have checked the thesis proposal and approved/ disapproved this candidate to the Thesis defense
Advisor's signature **[Signature]** Date **15/Nov/2021**
Informed for further actions to be taken
Candidate's signature **[Signature]** Date **15/Nov/2021** Time **15:30**

Downloadable from the department's web site:
<http://env.eng.chula.ac.th>
Carefully check the correct level (Master's/ Ph.D.) at the top section of the document



Example of the form

To inform the Head of the department for approval
Signature **(Assoc. Prof. Witoonluk Pungroem, PhD)**
Secretary to the Master Program Committee
Date.....

Approved
Signature **(Assoc. Prof. Khemarath Osathaporn)**
Head of Environmental Engineering department
Date.....

Submit the intent to defend your thesis (cont.)

2. Accompanying documents

2.1 Academic record (CR60) ←

โหลดจาก Reg-Chula

2.2 English proficiency test score (CU-TEP) ←

From CU-TEP system, if your score was qualified since your admission to the program, you can use the same score document.

2.3 Evidence from the faculty that your thesis proposal was approved

ผลการพิจารณาโครงร่างวิทยานิพนธ์/สารนิพนธ์ (นิสิต)

Chula iThesis <ethesis.grad@gmail.com>

Sat 12/8/2018 7:41 PM

To: Tanapong Ouppatampanon <6070204921@student.chula.ac.th>

สำเนาเรียนนิสิตชื่อ นายธนพงศ์ อุปลัมภานนท์

เรื่อง ผลการพิจารณาโครงร่างวิทยานิพนธ์/สารนิพนธ์

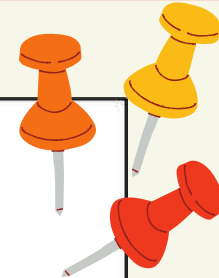
ระบบ CU iThesis ได้รับผลการพิจารณาโครงร่างวิทยานิพนธ์/สารนิพนธ์จากอาจารย์ที่ปรึกษาหลัก (รศ. ดร.วิบูลย์ลักษณ์ ฟังรัมย์) ของนิสิตชื่อ นายธนพงศ์ อุปลัมภานนท์ รหัส 6070204921 หลักสูตร วิศวกรรมศาสตรมหาบัณฑิต วิศวกรรมสิ่งแวดล้อม ภาควิศวกรรมสิ่งแวดล้อม คณะวิศวกรรมศาสตร์ หัวข้อ ประสิทธิภาพของถังปฏิกรณ์ไร้อากาศชนิดฟลูอิดไดซ์เบดแบบไม่เวียนน้ำที่ใช้พีวีเอเจลเป็นตัวกลาง (Performance of non-recirculation anaerobic fluidized bed with PVA-gel as media) เรียบร้อยแล้ว เมื่อวันที่ 8 ธันวาคม 2561 เวลา 19:40:53 น. โดยมีผลการพิจารณาเป็น "อาจารย์ที่ปรึกษาหลักเห็นชอบโครงร่างวิทยานิพนธ์"

จึงเรียนมาเพื่อโปรดทราบ

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บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

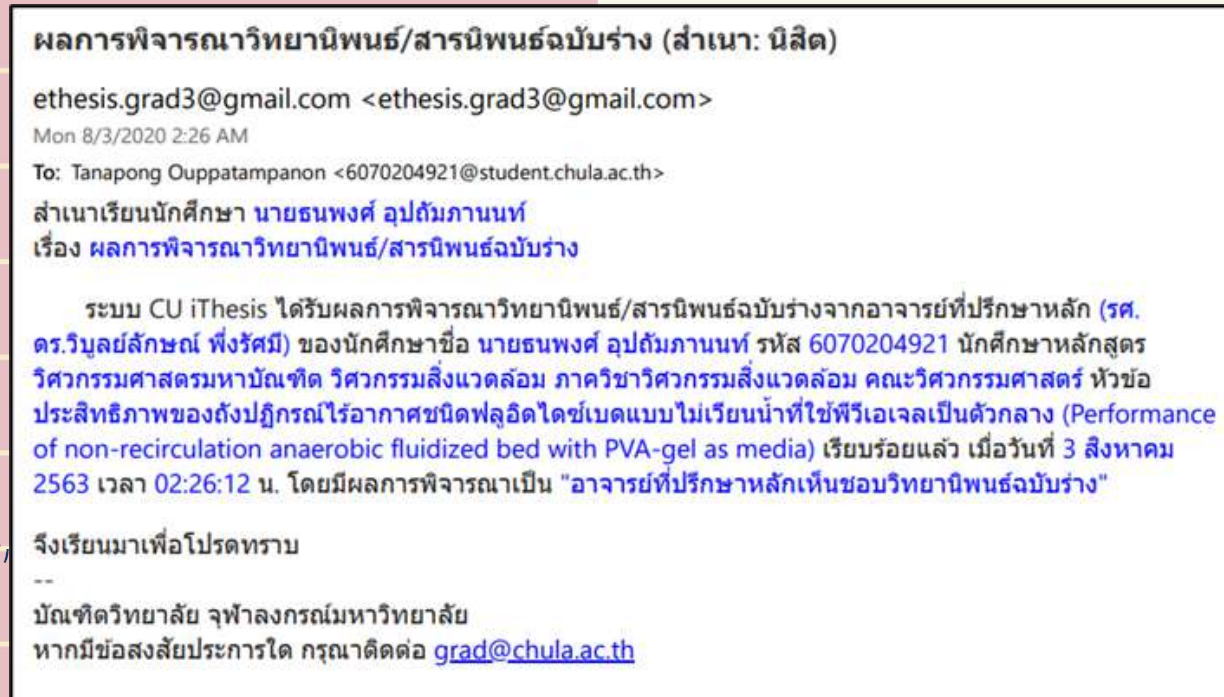
หากมีข้อสงสัยประการใด กรุณาติดต่อ grad@chula.ac.th



Example of thesis proposal approval

Submit the intent to defend your thesis (cont.)

2.4 Evidence of thesis upload to the CU-iThesis system with the confirmation from your advisor



Example of uploaded thesis confirmation

2.5 Evidence of publication/presentation (Certificate/email of acceptance for presentation)

2.6 English-language manuscript

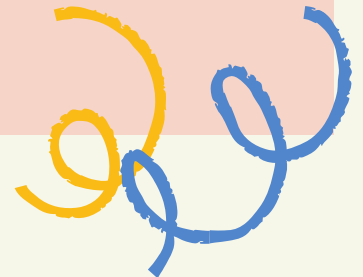
3. Thesis report file (1 separate file)

Submit your intent to defend

After preparing all documents, combine them in PDF format making documents in item 1 and 2 as one PDF file. Then send the combined file and the **thesis (item 3)** to the secretary email (thesisenvengcu@gmail.com)



After the administrative staff check the submitted application, you can make an appointment with the committee via Doodle www.doodle.com



Making an appointment by Doodle

- Pick time slots (8-10, 10-12, 13-15 and 15-17)
- Email the Doodle poll to all committee members and cc. to **thesisenvengcu@gmail.com** everytime. The email must have this attachment included

1. Assessment form before defense (B.3)
2. The link for Doodle poll
3. Thesis file

Example of an email sent to committee



Doodle Vote for Master Thesis Defense Date

Bonita Pen • BECIS - Commercial Industrial Solutions [View profile](#)

Bonita Pen <penbonita@gmail.com>
To: Khemarath Osathaphan; Pisut Painmanakul; Manaskorn Rachakaraj <manaskorn@gmail.com> +2
Cc: Manothai Srilaor

Dear All committee members,

I am Ms. Bonita PEN, a Master student from the Department of Environmental Engineering, Chulalongkornrajavidyalaya University, Bangkok, Thailand, to defend my thesis entitled " Removal of ferrous and arsenic from contaminated groundwater by coagulation-filtration-membrane separation process ".

The follows are a list of committee members:

1. Chairman: Asst. Prof. Manaskorn Rachakornkij, Ph.D.
2. Adviser: Prof. Pisut Painmanakul, Ph.D.
3. Co-adviser: Dr. Pattarasiri Fagkaew
4. Cluster: Assoc. Prof. Khemarath Osathaphan, Ph.D.
5. External committee: Asst. Prof. Marupatch Jamnongwong, Ph.D.

Would you please select your convenient date and time for my proposal defense?

https://doodle.com/poll/c2rdzee624wrr9ay?utm_source=poll&utm_medium=link

Thank you for your valuable time!

Best regards,

[← Reply](#) [← Reply all](#) [→ Forward](#)

After the defense date is finalized

*****email to confirm the date/time to all committee members (no need to send separately)**

- Prepare the form B.2 (download from the department's web site)

By signing in this order **student > advisor > chair > the program director**

and then send to **thesisenvengcu@gmail.com** and then wait for reply from the faculty

- Send the documents received from The Graduate School of Faculty of Engineering including the following (can be sent 3 days prior to the defense date)

1. Defense result report (**everyone**)

2. Publication report form (**everyone**)

*****attach with the form B.2 from the faculty*****

3. Assessment form for excellence achievement if qualified (**everyone**)

*****included with the form B.2 from the faculty if qualified*****

4. Defense assessment form (**everyone**)

5. Presentation slides (**everyone**)

6. Zoom link for the defense (**everyone**) (student creates the zoom link) watch instruction at <https://www.it.chula.ac.th/service/chulazoom/>

7. Invitation letter from the Faculty (email to external committee)



Revision after the defense

- Revise your thesis corresponding to the committee's comments shown in the Defense result report (discuss with each committee and your advisor to confirm where and how should the revision be made)
- Make a table summarizing your reviews as in the example. Indicate where and what were the revisions.
- Upload the finalized thesis report in iThesis system

Example of revision table →



Thesis Revision

Title : Removal of ferrous and arsenic from contaminated groundwater by co-precipitation coupling with membrane separation process

Student's name: Bonita Pen ID: 6272049021

Chapter	Page	Comment/Question	Revision/addition information
Assoc. Prof. Dr. Manaskorn Rachakarakij			
1. Recommendation	131 st	Adding MRLs of Arsenic and Iron in Groundwater	An MRL of 0.005 mg As/Kg/day has been derived for acute-duration (14 days or less) oral exposure to inorganic arsenic. An MRL of 0.0003 mg As/Kg/day has been derived for chronic-duration (365 days or more) oral exposure to inorganic arsenic.
2. Chapter 4	107 th - 109 th 95 th - 97 th	Validation Equation by Regression	Iron: $Y_1 = 0.8871x + 9.1499$ $R^2 = 0.8854$ $Y_2 = 0.6971x + 23.812$ $R^2 = 0.6972$ Arsenic: $Y_1 = 0.8591x + 11.196$ $R^2 = 0.8588$ $Y_2 = 0.534x + 34.887$ $R^2 = 0.5337$
Prof. Dr. Pisut Painmanakul			
3. Chapter 4	127 th	Diagram of arsenic and iron removal mechanism	Arsenic and iron removal by co-precipitation and adsorption diagram is shown on page 118 th
Assoc. Prof. Dr. Khemarath Osathaphan			
4. Recommendation	131 th	Further observation of co-precipitate particles	Co-precipitated particles should be analyzed by XRD or

Revision after the defense

Send email to the committee with these attachments

1. Thesis revision table
2. Thesis approval form (extract just this page from the thesis report)
3. Thesis defense result report



Email to committee to collect signatures in this order

Main advisor



Co-advisor



External committee



Cluster committee



chair

Report of the Examination
Faculty of Engineering Chulalongkorn University

Name: Miss Bonita Pen Student ID: 017209021
Major: Environmental Engineering Department Environmental Engineering Student Level of Master Degree
Semester: 1 Academic Year: 2021 Number of thesis credits: 12 Credits
Thesis Title in Thai: การศึกษาผลกระทบของสารพิษต่อสิ่งแวดล้อมและการบำบัดน้ำเสียด้วยกระบวนการแยกเมมเบรน
Thesis Title in English: EFFECT OF TOXIC SUBSTANCE ON ENVIRONMENTAL POLLUTION AND TREATMENT OF WASTEWATER BY MEMBRANE SEPARATION PROCESS
Thesis results: Score (BY SCORE) # (BY SCORE)
..... # (BY SCORE) # (BY SCORE)

Comments on a dissertation:

Please student signed every year in the committee and reporting result.

Signature: Chairman
Asst. Prof. Dr. Manaskorn Rachakarakul
..... Advisor
Prof. Dr. Pisut Painmanakul
..... Co-Advisor
Dr. Pattarasiri Fagkaew
..... Committee
Assoc. Prof. Dr. Khemarath Osathaphan
..... External Examiner
Asst. Prof. Dr. Marupatch Jannongwong

We have been notified of the dissertation examination result as well as the examination committee's opinion. Please send the examination result to the Faculty of Engineering Graduate Program.

(Signature)
Associate Professor Dr. Khemarath Osathaphan
Head of Department of Environmental Engineering

Thesis Title Removal of ferrous and arsenic from contaminated groundwater by co-precipitation coupling with membrane separation process

By
Field of Study Environmental Engineering
Thesis Advisor Professor PISUT PAINMANAKUL, Ph.D.
Thesis Co-Advisor Pattarasiri Fagkaew

Accepted by the FACULTY OF ENGINEERING, Chulalongkorn University
in Partial Fulfillment of the Requirement for the Master of Engineering

Dean of the FACULTY OF ENGINEERING
(Prof. SUPOT TEACHAVORASINSKUN, D.Eng.)

THESIS COMMITTEE

Chairman
(Assoc. Prof. Dr. MANASKORN RACHAKARAKUL)

Thesis Advisor
(Prof. Dr. PISUT PAINMANAKUL)

Thesis Co-Advisor
(Dr. Pattarasiri Fagkaew)

aminer
(Assoc. Prof. Dr. KHEMARATH OSATHAPHAN)

External Examiner
(Asst. Prof. Dr. Marupatch Jannongwong)

Example of approval form and thesis result report

Submit documents to The Graduate School and the Faculty

Once all committee have signed the thesis approval and thesis result report

- Go to the iThesis web page, then go to 'Report Data' section on the left panel
- Complete the information in 3 subsections***consult with your advisor how to fill information in each subsection***

After Defense

Plagiarism Detection will automatically show up after pressing in the final thesis

Plagiarism Detection: Percentage of similarity from Akarawisit
Totally agree : 1.67 %

Evaluation
 Very Good Good Passed Not Passed

Evaluation choose the evaluation result as the committee have decided

Dissemination through electronic media, publication, radio and television media
การเผยแพร่วิทยานิพนธ์ จะมีการส่งข้อมูลและวิทยานิพนธ์ที่ผ่านการประเมินแล้ว ไปให้คลังข้อมูลของสถาบันการศึกษา และส่งเอกสารและวิทยานิพนธ์ที่เป็น PDF ไปยัง สทอ. เพื่อเป็นฐานข้อมูลในการระงับการคัดลอกวรรณกรรมต่อไป
 Allowed
 Not Allowed to: 2021-07-10
reason: in process of patent request

Dissemination of full document on a website
การเผยแพร่วิทยานิพนธ์ จะมีการส่งข้อมูลและวิทยานิพนธ์ที่ผ่านการประเมินแล้ว ไปให้คลังข้อมูลของสถาบันการศึกษา และส่งเอกสารและวิทยานิพนธ์ที่เป็น PDF ไปยัง สทอ. เพื่อเป็นฐานข้อมูลในการระงับการคัดลอกวรรณกรรมต่อไป
 Allowed
 Not Allowed to: 2021-07-10
reason: in process of patent request

Dissemination please consult with your advisor regarding the choice of permission for dissemination through the various channels

- In case of allowing default permission, choose "Allowed"
- In case you choose to not allow, you have to indicate the limit until when that you do not allow along with the reason
EXAMPLE: Now allowed to 2021-07-10
= meaning that do not permit to disseminate this thesis until 10/7/2021 (after this date, it will be disseminated)

The page to fill information After Defense



Submit documents to The Graduate School and the Faculty

Research Mapping

YOUR PROFILE

ELECTRONIC FORM

REVISION & APPROVAL

REPORT DATA

SUBMISSION DOCUMENT

LITERATURE SEARCH 20

After Defense **Research Mapping** Publications

Engineering / Engineering (miscellaneous)

Thailand Standard Industrial Classification (TSIC)

A. Agriculture and agricultural industry development

B. Economic, social, educational and cultural researches

C. Science, Technology and Industry Development

D. Health Promotion

E. Humanities

The International Standard Classification of Education (ISCED)

Research Mapping is the categorization of the thesis subject for convenient searching

- **Thailand Standard Industrial Classification (TSIC)** is the main category that you can choose only 1
- **Letter A-E** is the subcategory that you can choose more than 1



Research Mapping selection page

Submit documents to The Graduate School and the Faculty

Publications

ARCH MANAGEMENT SYSTEM
University

After Defense Research Mapping **Publications**

Direction: To facilitate publication reporting to the institute, we have developed a real-time search tool to retrieve the publications from online citation databases automatically without any required data to fill-in the form by hand. However some publications are not stored in the database; in this case please add by hand on "Publication Form" and see the result on "Your Publications" menu.

Real time Search **Publication Forms** Your Publications

Publication Forms: Journal / Article Conference Intellectual

ISSN

OR

Source Name

Publication section contain the detail of publication of your work; there are 2 ways to search for published work

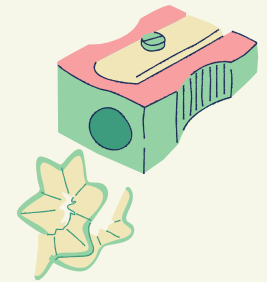
- **Real time search** you can search from Firstname/Lastname as appeared as author of the work
- **Publication forms** is a search from the publisher name and ISSN number of the publication

Note:
If you cannot search by both methods, then contact the Graduate School by sending email and including the details and evidence of your publication

Filling information in Publications section

Submit documents to The Graduate School and the Faculty

- After filling information in the 'Report Data' section
- Press submit to send the complete thesis for your advisor to approve
- After the advisor approves, the status will show 'Complete'



YOUR PROFILE	Revision & Status	Revise Completed Version	Approval History
ELECTRONIC FORM	Last update on electronic form 09 July 2020 16:59:11		
REVISION & APPROVAL	COMPLETE - THE EFFECTS OF SALINITY AND NITRATE ON CORAL HEALTH LEVELS IN BRANCHING CORAL (<i>Acropora sp.</i>) DISC CORAL (<i>Turbinaria sp.</i>) AND MASSIVE CORAL (<i>Porites sp.</i>)		
REPORT DATA	Plagiarism Detection 1.67%		
SUBMISSION DOCUMENT	DRAFT - THE EFFECTS OF SALINITY AND NITRATE ON CORAL HEALTH LEVELS IN BRANCHING CORAL (<i>Acropora sp.</i>) DISC CORAL (<i>Turbinaria sp.</i>) AND MASSIVE CORAL (<i>Porites sp.</i>)		
LITERATURE SEARCH 20	Plagiarism Detection 1.70%		
	PROPOSAL - THE EFFECTS OF SALINITY AND NITRATE ON CORAL HEALTH LEVELS IN BRANCHING CORAL (<i>Acropora sp.</i>) DISC CORAL (<i>Turbinaria sp.</i>) AND MASSIVE CORAL (<i>Porites sp.</i>)		
	Plagiarism Detection 0.00%		

Example of the thesis approval page in iThesis system

After the advisor approves the thesis, the student can no longer make any changes to the thesis. If there is really a need to make any change, you must indicate the page to edit and notify the advisor to allow the change then wait for the Graduate School staff to give permission to make changes

Submit documents to The Graduate School and the Faculty

After the advisor approves the thesis, the status will show 'Complete'

- Go to 'Submission Document', you can download the cover page to submit thesis
- ***after that the student sign and request the advisor to sign***

The screenshot shows a web application interface. On the left, a sidebar menu contains several options: 'YOUR PROFILE', 'ELECTRONIC FORM', 'REVISION & APPROVAL', 'REPORT DATA', 'SUBMISSION DOCUMENT' (highlighted with a red box), and 'LITERATURE SEARCH'. The main content area displays a document titled 'DOCUMENTS FOR SUBMISSION OF COMPLETE THESIS' from the 'INTEGRATED THESIS & RESEARCH MANAGEMENT SYSTEM' of the Graduate School, Chulalongkorn University. The document contains the following information: Student ID: 6170433321, Name: Miss Kittiya Samlansin, Field of Study: Environmental Engineering, Faculty/Institute/College: FACULTY OF ENGINEERING, Level of Study: Master of Engineering, Phone number: (blank), E-mail address: 6170433321@student.chula.ac.th, Topic: ผลของความเป็นกรดและไนเตรตต่อระดับสุขภาพในปะการังกิ่งก้าน (Acropora sp.) ปะการังจาน (Turbinaria sp.) และปะการังโต๊ะ (Porites sp.) THE EFFECTS OF SALINITY AND NITRATE ON CORAL HEALTH LEVELS IN BRANCHING CORAL (Acropora sp.) DISC CORAL (Turbinaria sp.) AND MASSIVE CORAL (Porites sp.), and Count the total of pages: 156 page(s). A red box highlights the download icon in the top right corner of the document viewer.


Example of the cover page of thesis submission document

Submit documents to The Graduate School and the Faculty

After the advisor signs the submission document

- Make an official letter (official letter head indicating the department) to send the thesis to the Faculty of Engineering (Form B.4)

มทว.บ.4



Memorandum

Department of Environmental Engineering, Faculty of Engineering, Chulalongkorn University
ENV 470/2021 Date 08 December 2021

Subject To sign the complete thesis

To Dean of faculty of Engineering

Attachment: One complete thesis

According to the thesis defense of Ms. Bonita Pen a student of Master's level, Student ID no. 627 20490 21 of Department of Environmental Engineering with thesis title; Removal of ferrous and arsenic from contaminated groundwater by co-precipitation coupling with membrane separation process on 29 November 2021 by zoom online meeting, the result of thesis defense was evaluated as Good and One complete thesis has been attached for your considerations.

Please consider the request for signing the complete thesis.

Respectfully yours,

Signature.....
(Assoc. Prof. Khemarath Osathapun)
Head of the Environmental Engineering department

I confirm that to complete my thesis, I do not plagiarize other works
..... candidate
(Ms. Bonita Pen)

Example of an official letter to send thesis to the Faculty

Submit documents to The Graduate School and the Faculty

After the advisor signs the submission document

- Fill information in 'Academic Presentation Report' and include the article (the whole file)

Graduate Program, Faculty of Engineering
Academic Presentation Report for Graduate Student

Academic presentation of graduate student by publishing in scientific journal at national or international level
or by presenting at national or international academic conference

Student ID no. 6272049021 Name Bonita Pen

Degree Master Doctoral Plan 1/A1 (Thesis) 2/A2 (Study Thesis) Others

Major Environment Department Environmental Engineering Advisor Prof.Pisut Painmanakul, Ph.D

Thesis Topic Removal of Ferrrous and Arsenic from Contaminated Groundwater by Co-precipitation Coupling with Membrane Separation Process

would like to inform the academic presentation report with exact details appeared in the academic journal or conference.

1. The 7th International Conference on Environment 2021 (ICEV2021)

Genre Already published in journal or unconditionally accepted at _____ Sent to journal at _____
 Presented in the conference at Malaysia (Online) Beal's List Publishers Journal Year 2021

Level International National Data base ISI SCOPUS TCI Others _____

2. _____

Genre Already published in journal or unconditionally accepted at _____ Sent to journal at _____
 Presented in the conference at _____ Beal's List Publishers Journal Year _____

Level International National Data base ISI SCOPUS TCI Others _____

3. _____

Genre Already published in journal or unconditionally accepted at _____ Sent to journal at _____
 Presented in the conference at _____ Beal's List Publishers Journal Year _____

Level International National Data base ISI SCOPUS TCI Others _____

Others obtained a patent obtained a petty patent filed a patent filed a petty patent others _____

Name/Code/Detail _____

Advisor's Signature [Signature] Student's Signature [Signature] Tel. 0925808547 Date 10/12/2021

Please fill in the information and return this form to Graduate school section, Faculty of Engineering, Tel. 0-2218-6329, FAX. 0-2218-6333 and attach a copy of publishing documents, cover, and journal contents or a complete conference proceeding in order to proceed the request for graduation.

Effect of Solid Media Addition on Mass Transfer and Bubble Dynamics in Bubble Column Reactor

Bonita Pen¹, Phaly Ham^{1,2,3}, Saret Bum³, Pattarasiri Fagkaew¹ and Pisut Painmanakul^{1,4,5*}

¹Department of Environmental Engineering, Faculty of Engineering,

Chulalongkorn University, Bangkok 10330, Thailand

²Faculty of Hydrology and Water Resources Engineering,

Institute of Technology of Cambodia, Phnom Penh 12156, Cambodia

³Water and Environment Research Unit, Research and Innovation Center,

Institute of Technology of Cambodia, Phnom Penh 12156, Cambodia

⁴Center of Excellence of Environmental and Hazardous Waste Management,

Chulalongkorn University, Bangkok 10220, Thailand

⁵Research Unit on Technology for Oil Spill and Contamination Management,

Chulalongkorn University, Bangkok 10330, Thailand

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Abstract. The development of a bubble column reactor (BCR) has been investigated in terms of various related aspects for improving gas-liquid mass transfer. However, a comprehensive analysis of additional solid media in the multi-phase reactor for enhancing oxygen transfer performance is still limited. Therefore, the present work aims to analyze the relative effect of different solid media types and operating conditions on oxygen mass transfer coefficient (K_La) and hydrodynamic bubble parameters, i.e., bubble size distribution (D_b) and bubble rising velocity (U_b), in BCR. It was tested with different types of solid media (plastic ring, scouring sponge, scouring pad, and activated carbon foam), superficial gas velocities (V_g) ($0.18 - 0.94 \times 10^3 \text{ m s}^{-1}$), and solid media loading (3% - 10%). The result found that the addition of solid media in BCR can enhance K_La value with rising V_g about 9% - 80% compared to the free solid media due to its effect on bubble break-up and bubble increasing velocity. Furthermore, the scouring sponge and scouring pad resulted in the optimum K_La at a loading of 3%, but the plastic ring and activated carbon foam reached the optimum K_La at the highest loading (10%). However, at higher loading (>3%), the scouring pad tended to lower K_La . This could be because too much loading promotes bubble coalescence and accumulates at the reactor bottom due to its higher density. At $V_g 0.91 \times 10^3 \text{ m s}^{-1}$, the bubble size distribution was found to be smaller D_b by scouring pad and plastic ring, 4.24mm and 4.47mm, and larger D_b by scouring sponge and activated carbon foam, 4.73mm and 4.61mm, respectively, compared to without adding solid media, 4.51mm. Indeed, due to the reduction of the free movement of rising bubbles by solid media, all solid media types appeared to decrease U_b by approximately 20% - 67% compared to non-additional media. Remarkably, the scouring sponge could provide the highest enhancement of K_La due to the effect of reducing bubble rising velocity, resulting in increased bubble retention time, not bubble break-up rate. Overall, the study concludes that a scouring sponge is recommended as the most effective solid media for improving oxygen mass transfer by enhancing bubble retention time in BCR.

INTRODUCTION

Mass transfer of oxygen from a gas form to a liquid form is a significant process parameter in gas-liquid contactor. The transfer of oxygen gas into a liquid is a gas absorption process required in many industrial processes, such as wastewater treatment by aerobic processes or biotechnology processes [1]. Typically, a bubble column reactor is a multi-phase reaction device commonly used by gas-liquid contactors. It has many benefits, including simple installation, low performance and maintenance costs, and high mass transfer rates [2]. However, the oxygen transfer is still limited from a gaseous phase to a liquid phase because of poor solubility in water [3]. Several researchers have

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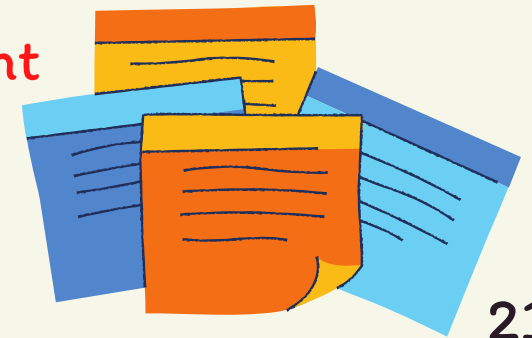
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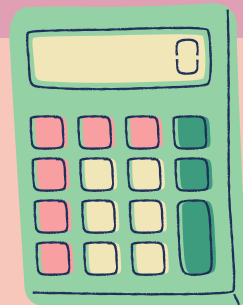
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น้ำดี (351)				
อุทกวิทยา (352)				
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