DEPARTMENT OF ENVIRONMENTAL ENGINEERING

FACULTY OF CIVIL, ENVIRONMENTAL AND GEO ENGINEERING

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

SYLLABUS

DOCTORAL PROGRAM (S3)

CURRICULUM 2018 – 2023

Catalog 2018

Doctorate Program (S-3)
Environmental Engineering

DEPARTMENT OF ENVIRONMENTAL ENGINEERING
FACULTY OF CIVIL, ENVIRONMENTAL AND GEO ENGINEERING
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FOREWORD

Assalammualaikum Wr Wb.
Best Wishes,

Praise be to Allah SWT because of His gifts and blessings we have finished the preparation of Curriculum 2018-2023 and make it happen in the Curriculum Catalog 2018. This catalog contains the composition of the subject, the number of credits and other information contained in the new curriculum of the Department of Environmental Engineering FTSLK ITS. Preparation of the curriculum 2018 - 2023 has been through various stages, including analysis of competency needs required by stakeholders and users of graduates, so expected results in the form of a curriculum that meets the standards of competence, comprehensive and update.

The Catalog 2018 is expected to provide information and guidance to the academic community, students, parents of students and all parties about learning materials, types of knowledge and skills learned, including the standards and learning objectives, references used, and the type of assessment undertaken by Department of Environmental Engineering FTSLK ITS. In the end, it is expected that the learning system based on the curriculum 2018-2023 will produce graduates that meet the achievement of learning that has been set, update, achievement and competitive, so easily absorbed in the job market and even able to create field and employment opportunities.
In the end, we hope that all the information contained in this book will be of the greatest benefit. Thank you.

Wassalammualaikum Wr. Wb

Surabaya, January 2018
Head of Department

Adhi Yuniarto, ST., MT., PhD.

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PROFILE

The Department of Environmental Engineering is under the Faculty of Civil, Environment and Geo Engineering - Institute of Technology Sepuluh Nopember. The Department of Environmental Engineering was established in 1996 with the Environmental Engineering S-1 Program which is a change from the Program Study S-1 (Undergraduate) Sanitary Engineering. Currently the Department of Environmental Engineering has three programs, which are:

1. S-1 (Undergraduate) Environmental Engineering
2. S-2 (Master) Environmental Engineering
3. S-3 (Doctorate) Environmental Engineering

Vision:

References in the field of engineering and environmental management of international repute in the improvement of environmental quality.

Mission:

1. Conducting undergraduate and postgraduate education in internationally reputable engineering and environmental management.
2. Develop science and technology in the field of environmental engineering and management that prioritizes the quality of the environment, including coastal areas.
3. Disseminate and actively apply technological innovation work and methods to solve environmental quality problems.
4. Capture partnership networks with government agencies and private / industry at home and abroad in the field of environmental engineering and management.
5. Develop ethical values, morals, attitudes and softskills of the academic community.

Educational Objectives:

1. Producing graduates who devoted to God Almighty, noble personality, ethical, academic morality, has a strong attitude and values.
2. Producing graduates capable of designing engineering engineering in the field of environmental engineering, producing innovations in preventing and implementing pollution controls, and applying

innovative technology and designing environmental remediation solutions from pollutants, which are oriented towards updating and disseminating them through scientific publications at the national or international level.

3. Mastering the basic principles of theoretical concepts of natural science, application of engineering mathematics, engineering principles, basic control technologies and environmental pollution prevention processes, and the basic principles of the latest and latest technologies, as well as the process of restoring the polluted environment.
4. Able to manage jobs and make the right decisions based on problem identification, information and data analysis with the insight of sustainable development (sustainable development) covering environmental aspects and settlement, marine, energy, and information technology as well as promoting social awareness.

S-1 (Undergraduate) Environmental Engineering Program

The S-1 (Undergraduate) Environmental Engineering Program was opened in 1983 based on the Decree of the Director General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia No. 116/DIKTI/Kep/1984 named the Sanitary Engineering Program under Department of Civil Engineering FTSP - ITS. In 1996, the Sanitary Engineering Program was turn into Environmental Engineering Program based on the Decree of the Director General of Higher Education Department of Education and Culture of the Republic of Indonesia No. 224/DIKTI/Kep/1996. This Study Program has been awarded by National Accreditation Board of Higher Education (BAN PT) with **Accreditation A** for the period of November 14, 2015 - November 14, 2020 based on the Decree of National Accreditation Board No. 1155/BAN-PT/Akred/S/XI/2015 14th November 2015.

S-2 (Master) Environmental Engineering Program

S-2 (Master) Environmental Engineering Program was opened in 1999 based on the Decree of the Director General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia Number 15/DIKTI/Kep/1999. S-2 (Postgraduate) Environmental Engineering Study Program has two areas of expertise, namely Environmental Engineering and Environmental Sanitation Engineering.

In the field of Environmental Engineering, it is reviewed various environmental problems and solutions with emphasis on academic studies for scientific development. The Environmental Sanitation Engineering focuses on academic studies applicable to the field of keciptakaryaan. This field of expertise is the cooperation of FTSP with Education and Training Center Ministry of Public Works of Indonesia.

The S-2 (Master) Program has been awarded National Accreditation Board of Higher Education (BAN PT) with **Accreditation A** rating for period 9th January 2015 – 9th January 2020 based on Decree of National Accreditation Board No. 005/BAN-PT/M/I/2015, dated 9th January 2015.

S-3 (Doctorate) Environmental Engineering Program

The S-3 (Doctorate) Environmental Engineering Program was opened in 2009 based on the Decree of the Director General of Higher Education, Ministry of National Education of the Republic of Indonesia Number 1250/D/T/2009 dated 31st July 2009. The study program accepts students from graduates of S-2 (Master) Environmental Engineering or others related background.

Academic Facility

- Lecturing Room
- Examination and Seminars Room
- Laboratories
- Computer Room and Internet Network
- Library (Reading Room)
- Magazines/ Scientific Journals
- Lecturer Room
- Administration room

Management of Department of Environmental Engineering:

1. Head of Department:
   Adhi Yuniarto, ST., MT., PhD.
2. Secretary of Department:
   Arseto Yekti Bagastyo, ST., MT., MPhil., PhD.
3. Head of S-1 Study Program :
   Bieby Voijant Tangahu, ST., MT., PhD.
4. Secretary of S-1 Program:
   Welly Herumurti, ST., MSc.
5. Head of S-2 and S-3 Study Program:
   Dr.Ir. Ellina S. Pandebesie, MT.
6. Secretary of S-2 and S-3 Program:
   Ipung Fitri Purwanti, ST., MT., PhD.
7. Head of Laboratory:
   - Laboratory of Water Recovery Technology
     Prof. Ir. Wahyono Hadi, MSc., PhD.
   - Laboratory of Air Pollution and Climate Change
     Dr. Eng Ari Dipareza Syafe'i ST., MEPM
   - Laboratory of Solid Waste and B3
     Prof. Dr. Yulinah Trihadiningrum, MAppSc.
   - Laboratory of Environmental Remediation
     Prof. Dr. Ir. Sarwoko Mangkoedihardjo, MScES.
   - Laboratory of Environmental Quality Management
     Prof. Dr. Ir. Nieke Karnaningroem, Dipl.SE,. MSc.

The Department of Environmental Engineering currently has a staff of 29 permanent lecturers consisting of 23 doctorates (5 Professors), 6 masters, and some lecturers from other departments who foster basic subjects and public lectures.

Permanent Lecturers of Department of Environmental Engineering, ITS

NO	NAME	GRADUATE FROM			EXPERTISE
		S1 (Under-graduate)	S2 (Master)	S3 (PhD)	
1	Prof. Ir. Wahyono Hadi, M.Sc. PhD.	ITB	State Univ. of South Dakota, USA	Univ. Leuven, Belgium	Water Treatment
2	Dr.Ir. M. Razif, MM.	ITB	ITB	UB	Environmental Development and Management
3	Prof. Dr. Yulinah Trihadiningrum, MApp.Sc.	ITB	Univ. of New South Wales, Australia	Univ. of Antwerpen, Belgium	Solid and Hazardous Waste Treatment
4	Prof. Dr. Ir. Sarwoko Mangkoedihardjo, M.ScES.	ITB	Univ. of Gent, Belgia	Univ. Brawijaya	Environmental Sanitation and Phytoremediation
5	Prof. Dr. Ir. Nieke Karnaningroem, MSc.	ITB	IHE, Holland	Civil Eng, ITS	Environmental Management & Modeling

NO	NAME	GRADUATE FROM			EXPERTISE
		S1 (Under-graduate)	S2 (Master)	S3 (PhD)	
6	Dr. Ir. Agus Slamet, MSc.	ITS	IHE, Holland	ITS	Waste Water Treatment
7	Prof. Ir. Joni Hermana, MScES., PhD.	ITB	Univ. of Gent, Belgium	Univ. of Newcastl, England	Waste Water Treatment, Environmental Management System
8	Ir. Atiek Moesriati, MKes.	ITS	Univ. Of Airlangga, Surabaya		Environmental Health
9	Ir. Eddy Setiadi Soedjono, Dipl.SE, MSc., PhD.	ITS	IHE, Belanda	Univ. of Birmingham England	Water and Sanitation
10	Ir. Mas Agus Mardyanto, ME., PhD.	ITS	Univ. of Roorkee India	Univ. of Otawa	Ground Water Management

NO	NAME	GRADUATE FROM			EXPERTISE
		S1 (Under-graduate)	S2 (Master)	S3 (PhD)	
11	Ir. Bowo Djoko Marsomo, MEng.	ITB	Asian Institute of Technology		Water Treatment
12	Dr.Ir. Ellina S. Pandebesie, MT.	ITB	ITS	Chemical Eng. ITS	Solid Waste Manag. & Technology
13	Dr. Ir. R. Irwan Bagyo Santoso, MT.	ITS	ITB	ITS	Environmental Resource Management.
14	Dr. Ali Masduqi, ST., MT.	ITS	ITB	Civil Eng, ITS	Water Supply Manag. & Engineering
15	Susi Agustina Wilujeng, ST., MT.	ITS	ITB	Currently studying in ITB	Wastewater Treatment & Solid Waste Management.

NO	NAME	GRADUATE FROM			EXPERTISE
		S1 (Under-graduate)	S2 (Master)	S3 (PhD)	
16	Dr. Ir. Rachmat Boedisantoso, MT.	ITS	ITB	ITS	Air Quality Control and Management
17	Bieby Voijant Tangahu, ST. , MT.., PhD.	ITS	ITS	UK Malaysia	Waste Water Treatment
18	IDAA Warmadewanthi, ST., MT., Ph.D.	ITS	ITB	NTUST, Taiwan	Solid Waste Treatment
19	Adhi Yuniarto, ST., MT., PhD.	ITS	ITS	UT Malay. Malaysia	Environmental Management
20	Harmin Sulistiyaningtitah, ST., MT., PhD.	ITS	ITB	UKM, Malaysia	Solid and Hazard. Waste, and Phytoremediation

NO	NAME	GRADUATE FROM			EXPERTISE
		S1 (Under-graduate)	S2 (Master)	S3 (PhD)	
21	Ipung Fitri Purwanti, ST., MT., PhD.	ITS	ITS	UKM, Malaysia	Environmental Sanitation
22	Alia Damayanti, ST., MT.,PhD.	ITS	ITS	UTM, Malaysia	Environmental Sanitation
23	Dr. Abdu Fadli Assomadi, S.Si., MT.	Univ. Brawijaya	ITS	ITS	Env. Chemistry & Air Quality
24	Dr. Eng Ari Dipareza Syafe'i ST., MEPM.	ITS	NTU, Taiwan	Hiroshima Univ., Japan	Environmental Management & Air Quality
25	Arseto Yekti Bagastyo, ST., MT., MPhil. , PhD.	ITS	ITS dan The Univ. of Queensland	Univ. of Queensland	Hazardous Waste(water) Treatment
26	Welly Herumurti, ST.., MSc.	ITS	Univ. Petronas, Malaysia		Environmental Management
27	Alfan Purnomo, ST., MT.	ITS	ITS		Wastewater Treatment

NO	NAME	GRADUATE FROM			EXPERTISE
		S1 (Under-graduate)	S2 (Master)	S3 (PhD)	
28	Ervin Nurhayati, ST., MT., PhD.	ITS	ITS	National Chiao Tung University, Taiwan	Water Recovery
29	Iftitah Rahmatika, ST., M. ng.	UI	AIT Bangkok	Currently stidying in Tokyo	Water Treatment Technology

INFORMATION

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LIST OF DOCTORAL PROGRAM COURSES

No.	Course Code	Course Name	credit
SEMESTER : I			
1	RE186101	Design of Doctoral Research	3
2	RE186102	Environmental Engineering Operation and Process	3
		Total credits	6
SEMESTER : II			
1		Elective Course 1	3
2		Elective Course 2	3
		Total credits	6
SEMESTER : III			
1	RE186301	Dissertation 1	8
		Total credits	8
SEMESTER : IV			
1		Dissertation 2	8
		Total credits	8
SEMESTER : V			
1		Dissertation 3	6
		Total credits	6
SEMESTER : VI			
1		Dissertation 4	6
		Total credits	6

LIST OF ELECTIVE COURSES

No.	Course Code	Elective Courses Name	credit
1	RE186201	Scientific Writing and International Publications	3
2	RE186202	Multi-Phased Pollutants Transfer	3
3	RE186203	Environmental Engineering Stochastic Method	3
4	RE186204	Applied Phytotechnology	3
5	RE186205	Applied Microbial Ecology	3
6	RE186206	Advanced Technology of Wastewater Treatment	3
7	RE186207	Advanced Technology of Solid Waste Treatment	3
8	RE186208	Advanced Technology of Hazardous Waste Treatment	3

COURSE	**Course Name**	: Design of Doctoral Research
	Course Code	: RE186101
	Credit	: 3 credits
	Semester	: 1

COURSE DESCRIPTION

This course will expand the students perspectives for preparing their doctoral research. Here, students will study research methodology, covering laboratory and field research design using experimental design approach, as well as the details of dissertation, including its philosophy. To deepen the understanding of students, in this course they will be subjected to many tasks to prepare a dissertation proposal: composing proposal material through the preparation stages and presenting the progress.

GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE

Attitude:

- mastering the philosophy of engineering science, engineering design, advanced methods and techniques necessary for the analysis and design of environmental engineering or environmental management systems
- giving the best effort to achieve perfect results
- demonstrating attitude of responsibility on work in his/her field of expertise independently

General Skill(s):

- able to develop logical, critical, systematic, and creative thinking through scientific research, the creation of design in science and technology that concerns about and applies the value of humanities in accordance with their field of expertise, prepares scientific conception and result of study based on scientific principles, procedures, and ethics in a form of thesis or other equivalent form, and uploaded in the university web page, as well as papers published in accredited scientific journals or accepted in international journals;
- able to perform academic validation or studies in accordance with their areas of expertise in solving problems in communities or relevant industries through the development of knowledge and expertise;
- able to formulate ideas, thoughts and scientific arguments in a responsible and academic manner, and communicate them through the media to the academic community and the wider community;

- able to identify the scientific field that became the object of their research and positioned into a research map developed through interdisciplinary or multidisciplinary approach
- able to make decisions in the context of solving problems of science and technology development that concerns with and implements the humanities value based on analytical or experimental studies of information and data;
- capable of managing, developing and maintaining networking with colleagues, peers within institutions and the broader research community;
- able to improve the capacity of learning independently; and
- capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism.

Knowledge:

- theory of engineering science, design engineering, advanced methods and techniques necessary for the analysis and design of environmental management efforts;
- system theory and application of advanced mathematical optimization; and
- interdisciplinary approach that is contextual and up to date related to the design of integrated environmental management systems.

Specific Skill(s):

- able to develop new knowledge and/or technology in the field of environmental engineering through research, to produce creative, original, and tested works
- able to solve engineering and technological problems, and to design systems, processes and components of environmental management efforts including management of drinking water, wastewater, solid waste, drainage system, and control system of wastewater, solid waste and gas pollutants, air pollution control and occupational health and safety (OHS) by utilizing other fields of science (if required) and taking into account the economic, public health and safety , cultural, social and environmental factors;
- able to deepen and expand proficiency in the field of design, operation, and maintenance of engineering systems and environmental management to give original and tested contribution through research independently;
- able to formulate new ideas (new research question) from the research conducted for the development of technology and environmental management system; and

- able to adapt the changes of science or technology that occur to the implementation process and the content of research faced in the field of environmental management

COURSE LEARNING OUTCOME
- Able to develop a research design in the field of environmental engineering or environmental management - Able to design innovative research in the field of environmental engineering in solving environmental problems of settlement and industry - Able to prepare a doctoral research proposal and design a dissertation organization
SUBJECTS
- Scientific/non-scientific research; the difference between undergraduate's thesis, master's thesis and doctoral's thesis (dissertation) - Types and methods of research - Design of Experiment: Research questions, sampling, determination of variables, research data collection, and research structure - Definitions of dissertation - Difference between master's & PhD's dissertations - Planning a dissertation - Organization of dissertation - Writing and presenting the thesis or dissertation - The thesis/dissertation defense
PREREQUISITE
REFERENCES
1. Estelle M. Phillips and Derek S. Pugh, "HOW TO GET A PhD, A handbook for students and their supervisors", Open University Press, England, 2005 2. Beach, D.P. and Torsten, K.E.A. 1992, Handbook for Scientific and Technical Research. Prentice Hall. Englewood Cliffs. 3. Greenfield, T(ed). 1996. Research Methods: Guidance for Postgraduates. Arnold. London.

4. Sproull, N. 1995. Handbook of Research Methods. The Scarecroe Press.
5. Creswell J. 1994. Research Design: Qualitative and Quantitative Approaches. Sage Pub. New Delhi.
6. Hedrick, T. et.al. 1993. Applied Research Design: A Practical Guide. Sage Pub. New Delhi.
7. Zar, Jerrold H., “Biostatistical Analysis”, 3rd Edition. Prentice – Hall. Englewood Cliffs, 1996
8. Berthouex, P.M. and Brown, L.C., “Statistics for Environmental Engineers” Lewis. Boca Raton, 1994
9. Shahin, M. van Oorschot, H.J.L. de Lange, S.J., “Statistical Analysis in Water Resource Engineering”, A.A. Balkema. Rotterdam, 1993

COURSE	**Course Name**	: Environmental Engineering Operation and Process
	Course Code	: RE186102
	Credit	: 3 credits
	Semester	: 1

COURSE DESCRIPTION

In this course, students will gain knowledge related to the operation and process of the treatment of water and wastewater, solid waste, and gaseous/particulate pollutants. Thereupon, student will be able to think critically and creatively to produce a development of a more functional science and technology. The course will be conducted by emphasizing on the exploration of students' ability so as to develop and deepen their previously gained scientific knowledge. Therefore, students are required to independently enrich their knowledge of subjects related to the operation and process of the treatment of water and wastewater, solid waste, and gaseous/particulate pollutants and discuss it in the classroom.

GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE

Attitude:

- Internalize academic values, norms, and ethics;
- Demonstrating attitude of responsibility on work in his/her field of expertise independently
- Internalizing the spirit of independence, struggle, and entrepreneurship.
- Trying his/her best to achieve perfect results
- Working together to be able to make the most of his/her potential.

Mastery of knowledge:

- Mastering the philosophy of engineering science, engineering design, advanced methods and techniques necessary for the analysis and design of environmental engineering or environmental management systems

Specific Skill(s):

- Able to develop new knowledge and/or technology in the field of

environmental engineering through research, to produce creative, original, and tested works.

General Skill(s):

- Capable of selecting appropriate, current, advanced, and beneficial research on humanity through interdisciplinary, multidisciplinary, or transdisciplinary approaches, in order to develop and / or produce problem solving in the fields of science, technology, art or society, based on the results of a study of the availability of internal and external resources.
- Being able to develop a roadmap of research with interdisciplinary, multidisciplinary, or transdisciplinary approaches, based on a study of the main objectives of the study and its constellations on broader objectives;
- Being able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community

COURSE LEARNING OUTCOME
- Able to think critically and creatively to produce a development of a more functional environmental science and technology - Able to develop the concept of operation and process of the treatment of water and wastewater, solid waste, and gaseous/particulate pollutants in accordance with local environmental conditions - Able to explore their ability so that the gained scientific knowledge can be developed to comprehensively solve environmental problems.
SUBJECTS
- Review of the operation and process of the conventional treatment of water and wastewater, solid waste, and gaseous/particulate pollutants. - Recent development of the up-to-date theories on operations and processes in environmental engineering, including water and wastewater treatment, solid waste treatment, and gaseous/particulate pollutants treatment. - The technology for physical treatment of water and wastewater, solid waste, and gaseous/particulate pollutants. - The technology for physico-chemical treatment of water and wastewater, solid waste, and gaseous/particulate pollutants. - The technology for biological treatment of water and wastewater, solid waste, and gaseous/particulate pollutants. - Technological development to obtain an effective and efficient design of the treatment of water and wastewater, solid waste, and gaseous/particulate pollutants.
PREREQUISITE
REFERENCES
1. David Hendricks, Water Treatment Unit Processes, Physical and Chemical, Talor & Francis, Bocca Raton, 2006 2. Jason F. McLennan, The Philosophy of Sustainable Design: The Future of Architecture, Ecotone Publishing Company, 2004 3. Chris Binnie, Martin Kimber, George Smethurst, Basic Water

Treatment, Thomas Telford Publishing, 2002
4. Pablo Lorenzano, Hans-Jörg Rheinberger, Eduardo Ortiz and Carlos Delfino Galles, History and Philosophy of Science and Technology - Volume IV, Eolss Publisher/UNESCO, 2010
5. David M. Kaplan, Philosophy, Technology, and the Environment, Massachusetts Institute of Technology, 2017

COURSE	**Course Name**	: Scientific Writing and International Publications
	Course Code	: RE186201
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION

In this course, students will study subjects related to scientific writing covering language, method, and presentation; preparing the concept in the form of scientific writing/national/international publications; identify and analyze problems, sources and processes of pollution in water, soil, and groundwater media in the form of scientific writing/national/ international publications; preparation of presentation materials. After joining this course, students will be able to write a readily-submitted scientific paper for international journals publication.
Task: Prepare a paper ready to be submitted to the journal publisher

GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE

Attitude:
- Internalize academic values, norms, and ethics
- Demonstrating attitude of responsibility on work in his/her field of expertise independently

General Knowledge:
- The method of writing theoretical and empirical scientific works; choice of publications media.

Specific Skill(s):
- Able to develop new and meaningful ideas in the field of environmental engineering.
- Able to produce theoretical scientific works.

General Skill(s):
- Able to publish new and meaningful ideas based on the study of theoretical scientific works.

COURSE LEARNING OUTCOME
• Able to internalize values, norms, academic ethics; show a responsible attitude towards the work independently by doing the task without doing plagiarism • Able to apply the theory of engineering science, engineering design, current methods and techniques required for the analysis and design of environmental engineering or environmental management systems in doing tasks independently • Able to develop logical, critical, systematic, and creative thinking through scientific research, creation of design in science and technology that concerns and implements the value of humanities in accordance with their field of expertise; prepares scientific conception and result of study based on scientific principles, procedures, and ethics • Able to deepen or expand their knowledge and expertise in the field of design, operation, and maintenance of engineering systems and environmental management to give original and tested contribution by doing review paper task
SUBJECTS
- Various types of research in the development of science and technology. - Finding research problem, research methodology implementation. - Language of scientific writing, scientific writing method, and presentation using standard official Indonesian language. - Task: prepare scientific papers to be published in journals/seminars.
PREREQUISITE
REFERENCES
1. Ethics in Research & Publication program: https://www.journals.elsevier.com/neuroscience-and-biobehavioral-reviews/policies/ethics-in-research-publication-program 2. Committee on Publication Ethics (COPE): https://publicationethics.org/ 3. Reference management: https://www.mendeley.com/

COURSE	**Course Name**	: Multi-Phased Pollutants Transfer
	Course Code	: RE186202
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION

Pollutants in the environment are in solid, liquid, and gaseous form. Subjects studied in this course covers: Changes of substance phase, contaminants, contaminants transport, transfer kinetics of pollutants between different media; fate and transport of contaminants. After attending this course, students will be able to develop a design of multi-phase pollution transport model to solve environmental problems.

GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE

Attitude:

- Appreciating the diversity of cultures, point of view, religion and belief as well as opinion or the original findings of others;
- Working together, having social sensitivity and caring for community and environment;
- Demonstrating attitude of responsibility on work in his/her field of expertise independently; and
- Internalizing the spirit of independence, struggle, and entrepreneurship

General Skill(s):

- Able to discover or develop new theories/ conceptions/ ideas, contribute to the development and practice of science and/or technology
- Able to develop interdisciplinary, multidisciplinary or transdisciplinary research, including theoretical and/or experimental studies of the respective field of science
- Able to develop arguments and solutions of scientific, technology based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically

Specific Skill(s):

- Able to develop new knowledge and/or technology in the field of environmental engineering through research, to produce creative,

original, and tested works;

- Able to solve engineering and technological problems in the field of environmental management through interdisciplinary, multidisciplinary or transdisciplinary approaches by taking into account economic, health and safety, public, cultural, social and environmental factors; and
- Able to conceptualize, design and implement research in the field of environmental management to generate useful new knowledge, technology or concepts.

Knowledge:

- The philosophy of engineering science, engineering design, advanced methods and techniques necessary for the analysis and design of environmental engineering or environmental management systems; and
- A substantial and leading edge body of knowledge through the acquisition of systematic knowledge in the field of science or practice engineering profession of environmental engineering.

COURSE LEARNING OUTCOME
• Students are able to think critically about environmental facts and create a map of problems based on theory and science • Students are able to determine the factors that become the root cause of environmental pollution problem and predict the target points of pollution that are most at risk in nature • Students are able to conceptualize problem-solving methods based on environmental facts and the sources or conditions that are most likely to be at risk • Students are able to create a comprehensive map of pollutants fate and transport in nature, and create a research design to solve it.
SUBJECTS
- Substance phase changes (parameters of substance phase changes, phase diagram, Clapeyron equation, gas properties); evaporation and evapotranspiration; Contaminants (organic, inorganic (heavy metals)); The nature of the substance (contaminants); - Contaminants transport (in subsurface, sorption and retardation, adsorption, absorption); Principles of diffusion mass transfer (flux, coefficient, steady and non-steady state, species conservation, boundary conditions or catalysis, steady state diffusion in stationary media (special case of one dimension)); - Kinetics of pollutants transfer between media (mass transfer model between media, contaminant mass transfer theory, mass transfer

model on two layers, mass transfer media in soil, mass transfer between aquatic plants-air);
- Fate and transport of contaminants (principles of fate and transport model classification schemes, processes affecting fate and contaminants transport)

PREREQUISITE

REFERENCES

1. Brodkey, Robert S, dan Harry C Hershey. Transport Phenomena, A Unified Approach. New York: McGraw-Hill Book Company, 1988.
2. Gonzalez, Noelia Ramirez. Organic Contaminant in Environmental Athmosphere and Waters. Tarragona: Department de Quimica Analitica Universitat Rovira I Virgil, 2011.
3. Mayer, A, and S Hassanizadeh. Soil and Groundwater Contamination: Nonaqueous Phase Liquids. American Geophysical Union, 2005.
4. Ramaswami, A., J.B. Milford, dan M.J Small. Integrated Environmental Modelling, Pollutant Transport, Fate, and Risk in the Environment. New Jersey: John Wiley & Sons, 2005.
5. Reynold, JP, JS Jerris, and L Theodore. Handbook of Chemical and Environmental Engineering Calculation. New York: A John Wiley and Sons, 2002.
6. Sawyer, Clair N, Perry L McCarty, and Gene F Parkin. Chemistry for Environmental Engineering and Science. fifth. Boston Burr Ridge: McGRAW-HILL, 2003.
7. Thibodeaux, LJ. Environmental Chemodynamic, Movement of Chemical in Air Water and Soil, 2nd ed. New York: Environmetal Science and Technology A Wiley Interscience Publication, John Wiley & Sons, Inc, 1996.
8. Singh, S. (2007). Physical Chemistry; State of matter: Gasoeus, Liquid, and Solids. Distt Meerut: Dept of Chemistry Janta Vedic P.G. College Baraut.
9. Manahan, Stanley E. Environmental Science, Technology, and Chemistry. Boca Raton: CRC Press LLC, 2000.
10. EPA. Introduction to Phytoremediation. Cincinnati, Ohio 45268: National Risk Management Research and Laboratory Office of R&D, US EPA/600/R-99/107, 2000.

COURSE	**Course Name**	: Stochastic Method of Environmental Engineering
	Course Code	: RE186203
	Credit	: 3 credits
	Semester	: Optional

SUBJECT DESCRIPTION

In this course, optimal decision-making and modeling of probabilistic environmental systems will be studied. This course contains optimization methods that provide an overview of stochastic problem-solving steps in environmental engineering decision making with a scientific and systematic approach. After attending this course, students will be able to distinguish between deterministic and stochastic or probabilistic environmental cases as well as able to solve stochastic cases by scientific method. The task that must be prepared by students is to conduct a stochastic environmental engineering case study and provide the appropriate solution using scientific method.

LEARNING ACHIEVEMENT OF GRADUATE WHICH IS CHARGED TO THE SUBJECT

Attitude:

- Demonstrating attitude of responsibility on work in his/her field of expertise independently

Mastery of Knowledge:

- Mastery of the philosophy of engineering science, engineering design, current methods and techniques necessary for the analysis and design of environmental engineering or environmental management systems

Specific skill(s):

- Able to solve engineering and technological problems in the field of environmental management through interdisciplinary, multidisciplinary or transdisciplinary approaches by taking into account economic, health and safety, public, cultural, social and environmental factors

General Skill(s):

- Capable of preparing interdisciplinary, multidisciplinary or transdisciplinary research, including theoretical and / or experimental studies in the fields of science, technology, art and innovation as outlined in the form of dissertations, and papers published in reputable international journalss

COURSE LEARNING OUTCOME
- Able to explain the philosophy of science, methods, and stochastic modeling techniques for the analysis and design of environmental engineering and management systems - Able to solve environmental problems using Markov, Time Series and Dynamic Systems - Able to conduct multidisciplinary research in both theoretical and/or experimental studies using stochastic modeling in environmental management and engineering
SUBJECTS
- Spectral analysis of time series process. - Theory of operation and prediction of a stationary process. - Univariate and multivariate spectral analysis, estimation of frequency response function. - Analysis and optimization of the random processes of linear and non-linear systems. - Network analysis, dynamic program, markov analysis, queuing theory and game theory. - Probability analysis, probability axiom, probability space, conditional probability, Bernoulli trials, asymptotic theorem, random functions and variables, characteristic functions, two-dimensional random variables, mean squared estimation, stationary processes, stochastic input systems, power spectrum, ergodicity, and spectral estimation.
PREREQUISITE
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REFERENCES
1. Papoulis A., Probability, Random Variables, and Stohastic Processes, 3rd Edition, McGraw-Hill, 1991. 2. Gardner, W.A, Introduction to Random Processes: With Application to Signals and Systems, Macmillan Pub. Co., 1986 3. Mooney, D.D. and Swift, R.J. 1999. A Course in Mathematical Modelling. The Mathematical Assosiation of America, Washington DC. USA.

4. Tien-Chang, L. 1998. Applied Mathematics in Hydrogeology. Lewis. Boca Raton.
5. Kernevez, J-P. 1997. The Sentinel Methods and Its Application to Environmental Pollution Problems. CRC. Boca Raton.
6. Carey, G. F. (Ed.). 1995. Finite Element Modelling of Environmental Problems –Surface and Subsurface Flow and Transport. John Wiley and Sons. New York.
8. Griffiths, D.V. and Smith, I.M. 1991. Numerical Methods for Engineers. Blackwell Scientific. Oxford UK.
9. Howard M. Taylor & Samuel Karlin, An Introduction to Stochastic Modeling, Academic Press, London
10. Hadlock, CR. 1988. Mathematical Modelling in The Environment. The Mathematical Assosiation of America, Washington DC. USA.
11. Taha, Operations Research, 1976, MacMillan Pubkishing Company, New York
12. Mokhtar S. Bazaara, Linear Prograamming, 1993, John Wiley & Sons, Inc. New York.

COURSE	**Course Name**	: Applied Phytotechnology
	Course Code	: RE186204
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION
In this course, students will learn the application of phytotechnology for the treatment of environmental pollution. The course materials includes: the phyto-process mechanism, the application of phytotechnology in infrastructure, waterbody and riparian area, wastewater treatment, remediation of polluted environmen, feasibility and design of, treatment and care of the post-used phytoremediation plants. Task: The case study of the application of phytotechnology.
GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE
Attitude: - Internalize academic values, norms, and ethics - Demonstrating attitude of responsibility on work in his/her field of expertise independently Mastery of Knowledge: - Able to solve environmental technology problems with inter, multi, or transdisciplinary phytotechnological approach. Specific skill(s): - Able to conceptualize, design and implement research in the field of phytotechnology to generate new, rewarding knowledge, technology or concepts. - Mastering the philosophy of science of engineering science, engineering design, methods and techniques necessary to develop phytotechnology as dissertation support. General Skill(s): - Able to apply phytotechnology in environmental management as outlined in the dissertation.

COURSE LEARNING OUTCOME
- Able to integrate the application of phytotechnology in the development of environmental infrastructure and remediation of polluted media. - Able to analyze and synthesize environmental problems by using phytotechnology. - Able to develop environmental pollution prevention program using phytotechnology approach. - Able to develop up-to-date design and research in the field of phytotechnology to solve environmental problems
SUBJECTS
- A review of the phyto-process mechanism discusses plant processes to respond to the quality and quantity of environmental factors exposed to the plant ecosystems - Application of phytotechnology in infrastructure: waterbody and riparian area - Application of phytotechnology for wastewater treatment - Application of phytotechnology for remediation of contaminated environment - Feasibility and design of phytotechnology
PREREQUISITE
REFERENCES
1. Mangkoedihardjo, S. dan G. Samudro. Fitoteknologi Terapan (Applied Phytotechnology), Yogyakarta: Penerbit Graha Ilmu, 2009. 2. Landmeyer, James E. 2011. Introduction to Phytoremediation of Contaminated Groundwater - Historical Foundation, Hydrologic Control, and Contaminant Remediation. Springer. Berlin. 3. The phytotechnology article, which has been published in international journals.

COURSE	**Course Name**	: Applied Microbial Ecology
	Course Code	: RE186205
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION

In this course, students will learn about chemicals thermodynamic modeling, transformation and kinetics, nutrient cycle related to microbial activity. The process of remediation by plant's root microbes. Case study of microbial applications in the process of fertility of dry and wet soils. Microbial remediation case studies on polluted land and coastal and marine ecosystems.

GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE

Attitude:
- Internalize academic values, norms, and ethics
- Demonstrating attitude of responsibility on work in his/her field of expertise independently

Mastery of Knowledge:
- Able to solve the problems of environmental technology with microbiological approach by scientific inter, multi, or trans-discipline .

Specific skill(s):
- Able to conceptualize, design and implement research in the field of microbiology to generate new, useful, knowledge, technology or concept.
- Mastering the philosophy of science engineering, engineering design, methods and current techniques necessary to develop microbiology as a dissertation support.

General Skill(s):
- Able to apply microbiology in environmental management as outlined in the dissertation.

COURSE LEARNING OUTCOME
- Able to integrate the application of microbiology in the development of environmental infrastructure and remediation of polluted media. - Able to analyze and synthesize environmental problems by using microbiology. - Able to develop environmental pollution prevention program using microbiological approach. - Able to develop up-to-date design and research in the field of microbiology to solve environmental problems.
SUBJECTS
- An in-depth review of thermodynamic modeling of chemicals, transformations, and kinetic, microbial and/or energy mediated-based nutrient cycles. - Co-process of microbes-plant's root. - Microbial case studies in the process of fertility of dry and wet soils. - Case study of microbial dynamics on land and coastal and marine management. - Microbial remediation case studies on polluted land and coastal and marine ecosystems.
PREREQUISITE
REFERENCES
1. Buscot, F. & Varma, A. (ed). 2005. Microorganisms in Soils : Roles in Genesis and Functions. Springer. Berlin 2. Kumar, P. 2002. Biological Control of Environmental Pollution. Sarup. New Delhi., India. 3. The phytotechnology article, which has been published in international journals.

COURSE	**Course Name**	: Advanced Technology of Wastewater Treatment
	Course Code	: RE186206
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION
GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE
Attitude: - Internalize academic values, norms, and ethics; - Demonstrating attitude of responsibility on work in his/her field of expertise independently - Internalizing the spirit of independence, struggle, and entrepreneurship. - Trying his/her best to achieve perfect results - Working together to be able to make the most of his/her potential Mastery of knowledge: - The philosophy of engineering science, engineering design, advanced methods and techniques necessary for the analysis and design of environmental engineering or environmental management systems. Specific skill(s): - Able to conceptualize, design and implement research in the field of environmental management to generate useful new knowledge, technology or concepts. General skill(s): - Capable of selecting appropriate, current, advanced, and beneficial research on humanity through interdisciplinary, multidisciplinary, or transdisciplinary approaches, in order to develop and / or produce problem solving in the fields of science, technology, art or society, based on the results of a study of the availability of internal and external resource.

- Able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community.
- Able to develop and maintain collegial and welfare relationships within their own environment or through networks of collaboration with non-institutional research communities.

COURSE LEARNING OUTCOME
- Able to understand the development of wastewater treatment technology - Able to recommend alternative of advanced wastewater treatment as a scientific solution for environmental pollution problems - Able to communicate with peers and colleagues in order to disseminate advanced technology of wastewater treatment.
SUBJECTS
PREREQUISITE
REFERENCES
1. Nicholas P. Cheremisinoff Biotechnology for Waste and Wastewater Treatment, Noyes Publications, New Jersey, USA, 1996. 2. Paola Foladori, Gianni Andreottola, dan Giuliano Ziglio, Sludge Reduction Technologies in Wastewater Treatment Plants, IWA Publishing, London, 2010. 3. Joo-Hwa Tay, Stephen Tiong-Lee Tay, Yu Liu, Kuan Yeow Show, dan Volodymyr Ivanov, Biogranulation Technologies for Wastewater Treatment: Microbial Granules, Elsevier, Netherland, 2006. 4. Thomas Stephenson, K. Brindle, Simon Judd, Bruce Jefferson, Membrane Bioreactors for Wastewater Treatment, IWA Publishing, London, 2006. 5. Juan M. Lema, Sonia Suarez Martinez, Innovative Wastewater

Treatment & Resource Recovery Technologies: Impacts on Energy, Economy and Environment, IWA Publishing, London, 2017.& Hiemstra, Wim. 1996. Biotechnology Building on Farmers' Knowledge. Macmillan. London.

COURSE	**Course Name**	: Advanced Technology of Solid Waste Treatment
	Course Code	: RE186207
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION

GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE

Attitude:

- Law abiding and disciplined in community and state life
- Internalizing academic values, norms and ethic
- Demonstrating attitude of responsibility on work in his/her field of expertise independently
- Internalizing spirit of independence, struggle and entrepreneurship.
- Trying his/her best to achieve perfect results, and

Working together to be able to make the most of his/her potential..

Mastery of knowledge:

- The philosophy of engineering science, engineering design, advanced methods and techniques necessary for the analysis and design of environmental engineering or environmental management systems.
- A substantial and cutting edge body of knowledge through the acquisition of systematic knowledge in the field of science or professional practice in the field of environmental engineering

Specific skill(s):

- Able to develop new knowledge and/or technology through research, to produce creative, original, and tested works;
- Able to solve engineering and technological problems in the field of solid waste management through interdisciplinary, multidisciplinary or transdisciplinary approaches by taking into account economic, health and safety, public, cultural, social and environmental factors; and

- Able to conceptualize, design and implement research in the field of solid waste management to generate useful new knowledge, technology or concepts

General skill(s):

- Able to discover or develop new theories or concepts or scientific ideas, contribute to the development and practice of science and / or technology that concerns and implements the value of the humanities in its field of expertise, by producing scientific research based on scientific methodology, logical thinking, critical, systematic, and creative

COURSE LEARNING OUTCOME
Able to select applicable, current, advanced, and beneficial research through a multidisciplinary approach in order to develop and/or produce problem solving in the field of waste management science and technology
SUBJECTS
PREREQUISITE
REFERENCES

1. ASTM (2011) Standard test method for determination of the composition of unprocessed municipal solid waste: ASTM D5231-92. ASTM International, West Conshohocken
2. Tchobanoglous G, Theisen H, Vigil SA (1993) Integrated solid waste management, engineering principles issues. McGraw Hill International Editions, New York
3. Zurbrugg C (2002) Urban solid waste management in low-income countries of Asia. How to cope with the garbage crisis. Scientific Committee on Problems of the Environment (SCOPE) Urban Solid Waste Management Review Session, Durban, South Africa, November 2002

COURSE	**Course Name**	: Advanced Technology of Hazardous Waste Treatment
	Course Code	: RE186208
	Credit	: 3 credits
	Semester	: Optional

COURSE DESCRIPTION
GRADUATE LEARNING OUTCOME MANDATED TO THE COURSE
Attitude • Law abiding and disciplined in community and state life • Internalizing academic values, norms and ethic • Demonstrating attitude of responsibility on work in his/her field of expertise independently • Internalizing spirit of independence, struggle and entrepreneurship. • Trying his/her best to achieve perfect results, and Working together to be able to make the most of his/her potential General Skill(s) • Being able to discover or develop new theories or concepts or scientific ideas, contribute to the development and practice of science and / or technology that concerns and implements the value of the humanities in its field of expertise, by producing scientific research based on scientific methodology, logical thinking, critical, systematic, and creative Mastery of Knowledge • The philosophy of engineering science, engineering design, advanced methods and techniques necessary to carry out quality research in the field of hazardous waste management • A substantial and cutting edge body of knowledge through the

acquisition of systematic knowledge in the field of science or professional practice in the field of environmental engineering

Specific Skill(s)

- Able to develop new knowledge and/or technology through research, to produce creative, original, and tested works;
- Able to solve engineering and technological problems in the field of hazardous waste management through interdisciplinary, multidisciplinary or transdisciplinary approaches by taking into account economic, health and safety, public, cultural, social and environmental factors; and
- Able to conceptualize, design and implement research in the field of hazardous waste management to generate useful new knowledge, technology or concepts

COURSE LEARNING OUTCOME
Able to select applicable, current, advanced, and beneficial research through a multidisciplinary approach in order to develop and/or produce problem solving in the field of science and technology of hazardous waste management
SUBJECTS
PREREQUISITE
REFERENCES

1. Trihadiningrum, Y., 2016. Pengelolaan limbah bahan berbahaya dan beracun. Teknosain, Yogyakarta.
2. Government Regulation No. 101 of 2014 on the Management of Hazardous and Toxic Waste.
3. LaGrega, M.D., P.L. Buckingham, dan J.C. Evans, 2001. Hazardous waste management. Second Edition. McGraw-Hill International Editions, New York

4. Blackman, W. C., 2004. Basic hazardous waste management.- 3rd. Edition". CRC
5. Pichtel, J., 2005. Waste management practices - municipal, hazardous, and industrial. CRC