



# **E3S** **Web of Conferences**

## PREFACE

The 1<sup>st</sup> International Conference on Applied Sciences and Smart Technologies (InCASST 2023) has been organized by the Faculty of Science and Technology, Sanata Dharma University, Yogyakarta, Indonesia. This event was held on October 18–19, 2023, in Yogyakarta, Indonesia. As an effort to contribute in distributing research outcomes, especially in the search for renewable and clean energy, waste management, environmental management, and sustainable agriculture. InCASST 2023 presented four honorable international keynote speakers from representative countries: 1) Prof. Tokuro Matsuo, Advanced Institute of Industrial Technology - Japan; 2) Prof. Ir. Sudi Mungkasi, Ph.D., Sanata Dharma University-Indonesia; 3) Assoc. Prof. Dr. Peerapong Uthansakul, Suranaree University of Technology – Thailand, and 4) Assist. Prof. Dr. Eng. Rando Tungga Dewa, The Republic of Indonesia Defense University-Indonesia. This event selected local researchers and overseas fellows to share their best research works at this conference to reach a broader network of researchers. After a rigorous selection process, the Scientific & Editorial Board decided to publish 46 papers in E3S Web of Conferences, open-access proceedings in environment, energy, and earth sciences, managed by EDP Sciences, and indexed on Scopus, Scimago.

The published papers have passed all necessary improvement requirements following the Web of Conferences standard, reviewer's comments, and similarity tests by the Turnitin program. We want to thank the official committee, scientific & editorial boards, and organizing partners. Thanks to our co-host partners, Universitas Katolik Widya Mandala Surabaya, Universitas Prasetya Mulya, and Institut Teknologi Nasional Yogyakarta, for trusting and supporting this conference. Finally, we would like to briefly thank all presenters and attendees for their participation in sharing wonderful ideas and making creative decisions to inspire further research and exchange scientific reasons. We hope this time, all papers can be compiled into scientific works as the first publication of the 2023 InCASST. Lastly, we hope this conference encourages further research collaboration and see you at the next conference.

Assoc. Prof. Dr. Ir. Bernadeta Wuri Harini  
**Conference chair**

## **Advisory board**

- Prof. Dr. Willy Susilo (Wollongong University, Australia)
- Apichate Maneewong, Ph.D. (Institute of Nuclear Technology, Thailand)
- Pham Nhu Viet Ha (Vietnam Atomic Energy Institute, Vietnam)
- Dr. rer. nat. Wolfgang Bock (Department of Mathematics, Rheinland-Pfalz Technical University, Germany)
- Dr. Bambang Dwi Wijanarko, S. Si, M.Kom. (Universitas Bina Nusantara, Semarang, Indonesia)
- Dr. Ir. Feri Yusivar, M.Eng (Universitas Indonesia, Indonesia)
- Dr. Irma Saraswati, M.Sc. (Universitas Sultan Ageng Tirtayasa, Indonesia)
- Dr. Imamul Muttakin (Universitas Sultan Ageng Tirtayasa, Indonesia)
- Dyonisius Dony Ariananda, S.T., M.Sc., Ph.D. (Universitas Gadjah Mada, Indonesia)
- Dr. Ir. Ford Lumban Gaol, S.Si., M.Kom. (Universitas Bina Nusantara, Indonesia)

## **Steering Committee**

- Conference Chairperson : Ir. Drs. Haris Sriwindono, M.Kom, Ph.D. (Sanata Dharma University - Indonesia)
- Member  
Dr. Ir. I Gusti Ketut Puja (Sanata Dharma University - Indonesia)  
Prof. Frans Susilo, SJ, (Sanata Dharma University - Indonesia)  
Prof. Ir. Sudi Mungkasi, Ph.D (Sanata Dharma University - Indonesia)

## **Organizing Committee**

- Conference chair : Dr. Ir. Bernadeta Wuri Harini (Sanata Dharma University - Indonesia)
- Conference co-chair : Dr. Eng. Ir. I Made Wicaksana Ekaputra (Sanata Dharma University - Indonesia)
- Member  
Ir. Theresia Prima Ari Setiyani, M.T. (Sanata Dharma University - Indonesia)  
Ir. Augustinus Bayu Primawan, D.Tech.Sc. (Sanata Dharma University - Indonesia)  
Regina Chelinia Erianda Putri, M.T. (Sanata Dharma University - Indonesia)  
Ir. Stefan Mardikus, M.T. (Sanata Dharma University – Indonesia)  
Rosalia Arum Kumalasanti, M.T. (Sanata Dharma University – Indonesia)  
Dr. Ir. Ridowati Gunawan, S.Kom., M.T. (Sanata Dharma University-Indonesia)

## **Editor**

- Ir. Damar Widjaja, Ph.D (Sanata Dharma University - Indonesia)
- Dr. Lusia Krismiyati Budiasih (Sanata Dharma University-Indonesia)



# InCASST

International Conference on  
Applied Sciences and  
Smart Technologies



## Science and Technology Disruption in the Post Pandemic Era with Sustainable Development for Better Life Quality

18<sup>th</sup> October, 2023

### Keynote Speakers



Prof. Ir. Sudi Mungkasi, Ph.D.  
Sanata Dharma University  
Indonesia



Assoc. Prof. Dr. Peerapong Uthansakul  
Suranaree University of Technology  
Thailand



Prof. Tokuro Matsuo  
Advance Institute of Industrial  
Technology  
Japan



Asst. Prof. Dr. Rando Tungga Dewa  
The Republic of Indonesia Defense  
University  
Indonesia

### Call For Paper

Selected papers will be publication to E3S Web of Conferences ( Scopus Indexed ).

### Scopes

- Renewable energy technologies and systems.
- Climate change and global warming.
- Sustainable agriculture and land use practices.
- Environmental impact assessment and management.
- Energy policy and planning.
- Clean energy and green technologies.
- Waste management and recycling.
- Air and water pollution control.
- Environmental biotechnology and microbiology.
- Carbon capture and sequestration.

### Important Dates

- Extended New Submission : August 15, 2023  
(Full Paper only)
- Accepted Notification : August 22, 2023
- Early Bird payment : April 30, 2023
- Late payment : August 31, 2023
- Full Paper Submission : September 18, 2023  
of Accepted Abstract
- Conference Day : October 18, 2023

### Registration :

<https://e-conf.usd.ac.id/Index.php/Incasst/Incasst2023>



### Registration Fee :

#### Presenter :

- Offline :
  - Early bird : Rp. 3.250.000 / US\$235
  - Late : Rp. 3.500.000 / US\$250
- Online :
  - Early bird : Rp. 2.950.000 / US\$185
  - Late : Rp. 3.200.000 / US\$200

#### Non-Presenter :

- Full Board : Rp. 750.000 / US\$60
- Gala Dinner : Rp. 250.000 / US\$25

#### Payment Method :

- Paypal : [suryagovinda@yahoo.com](mailto:suryagovinda@yahoo.com)
- Bank Transfer
  - Acc. No : 0373733749
  - Acc. Name : I Gusti Ketut Puja
  - Bank Name : BCA Cabang Yogyakarta or  
Bank Central Asia Indonesia  
Jakarta 10310, Indonesia  
BCA Swift Code : CENAIDJA

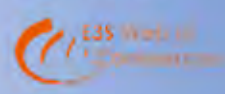
#### Contact Persons :

Sri Hartati Wijono (+62)8112646471  
Rosalia Arum Kumalasanti (+62)88232542165

#### Co-Host :



#### Publisher :



#### Venue :

Eastparc Hotel, Yogyakarta, Indonesia

[All issues](#) ▶ Volume 475 (2024)

[◀ Previous issue](#)

[Table of Contents](#)

[Free Access](#) to the whole issue

## E3S Web of Conferences

Volume 475 (2024)

### InCASST 2023 - The 1<sup>st</sup> International Conference on Applied Sciences and Smart Technologies

Yogyakarta, Indonesia, October 18-19, 2023

D. Widjaja and L.K. Budiasih (Eds.)

Export the citation of the selected articles [Export](#)

[Select all](#)

Open Access

#### About the conference

Published online: 08 January 2024

PDF (205 KB)

Open Access

#### Statement of Peer review

Published online: 08 January 2024

PDF (434 KB)

◻ [Clean Energy and Green Technologies](#)

◻ [Environmental Impact Assessment and Management](#)

## - *Clean Energy and Green Technologies*

Open Access

Effect of curing temperature on the mechanical properties of coconut shell nano carbon reinforced composites with epoxy matrix 01001

Petrus Iwan and I. Gusti Ketut Puja

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501001>

[Abstract](#) | [PDF \(2.541 MB\)](#) | [References](#)

---

Open Access

The role of nanocatalyst of pearl oyster shell in pack carburizing process on mechanical and physical properties of AISI 1020 steel 01002

Muhammad Rafi, I. Gusti Ketut Puja and Rines Rines

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501002>

[Abstract](#) | [PDF \(2.299 MB\)](#) | [References](#)

---

Open Access

Transparent carbon capture and storage using blockchain technology 01003

Gabriela Aristia and Khondaker Salehin

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501003>

[Abstract](#) | [PDF \(2.853 MB\)](#) | [References](#)

---

Open Access

Investigation of Eichhornia crassipes as a natural fibre in PMC for noise controller 01004

Paulina Dwi Nawanti, Dionisius Brian Deva Erwandha, Budi Setyahandana and I.M.W. Ekaputra

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501004>

[Abstract](#) | [PDF \(2.367 MB\)](#) | [References](#)

---

Open Access

Exploring the potential of GO-based composite hydrogels and their swelling property for controlled drug delivery 01005

Aning Ayucitra and Yi-Hsu Ju

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501005>

[Abstract](#) | [PDF \(2.583 MB\)](#) | [References](#)

---

Open Access

The effect of chassis weight optimization on the carbon footprint of the electric prototype vehicle 01006

Heryoga Winarbawa and Andreas Prasetyadi

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501006>

[Abstract](#) | [PDF \(1.765 MB\)](#) | [References](#)

---

Open Access

Alternative method for stopping the coconut shell charcoal briquette drying process 01007

Andreas Prasetyadi, Rusdi Sambada and Petrus Kanisius Purwadi

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447501007>

[Abstract](#) | [PDF \(1.809 MB\)](#) | [References](#)

---

## **- *Environmental Impact Assessment and Management***

Open Access

Replication control strategy based on a simple game of life in opportunistic networks 02001

Vittalis Ayu, Bambang Soelistijanto and Yasintha Putri Larasati

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502001>

[Abstract](#) | [PDF \(2.027 MB\)](#) | [References](#)

---

Open Access

The impact assessment of automated drip infusion control using weighing scale and pinch method on subjects 02002

Lanny Agustine, Made Indra Ayu Astarini, Maria Manungkalit, Jose Amadeus and Hartono Pranjoto

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502002>

[Abstract](#) | [PDF \(2.148 MB\)](#) | [References](#)

---

Open Access

Analysis of coal facies and parting in The Balikpapan formation, Kutai Basin, East

Kalimantan 02003

Roni Fauzan, R.A.T. Listyani and Setyo Pambudi

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502003>

[Abstract](#) | [PDF \(2.655 MB\)](#) | [References](#)

---

Open Access

Distribution model, depositional environment and facies of coal in the AE field, Kutai Kartanegara area, East Kalimantan 02004

Taufiq Erlangga Sutedjo, Setyo Pambudi, R.A.T. Listyani and Oky Sugarbo

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502004>

[Abstract](#) | [PDF \(2.891 MB\)](#) | [References](#)

---

Open Access

Fast fashion revolution: Unveiling the path to sustainable style in the era of fast fashion 02005

Tiara Nur Anisah, Andika Andika, Danang Wahyudi and Bimo Harnaji

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502005>

[Abstract](#) | [PDF \(2.303 MB\)](#) | [References](#)

---

Open Access

A method for assessing green value chain readiness 02006

Ivan Gunawan, Dian Trihastuti, Lusia Permata Sari Hartanti and Ivan Keane Hutomo

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502006>

[Abstract](#) | [PDF \(2.346 MB\)](#) | [References](#)

---

Open Access

Study of population distribution and benefits of Nipah (*Nypa fruticans*) 02007

Syaiful Eddy, Mirna Taufik, Andi Arif Setiawan, Budi Utomo and Maharani Oktavia

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502007>

[Abstract](#) | [PDF \(4.098 MB\)](#) | [References](#)

---

Open Access

Development of digital livestock monitoring in Sambilawang Village, Serang, Banten 02008

Sesaria Kikitamara, Izzahtul Mujahidah and Permata Nur Miftahul Rizky



Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502008>

[Abstract](#) | [PDF \(2.344 MB\)](#) | [References](#)

---

Open Access

### Comparison of the K-Means method with and without Principal Component Analysis (PCA) in predicting employee resignation 02009

Iwan Binanto and Andrianto Tumanggor

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502009>

[Abstract](#) | [PDF \(3.162 MB\)](#) | [References](#)

---

Open Access

### Key determinant of visitors' environmentally responsible behavior at Mlarangan Asri Beach Kulon Progo Regency, Indonesia 02010

Erni Umami Hasanah, Yumarlin MZ, Retno Lantarsih, Iwan Aminto Ardi, Danang Wahyudi, Andika and Della Nanda Luthfiana

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502010>

[Abstract](#) | [PDF \(1.941 MB\)](#) | [References](#)

---

Open Access

### Reuse strategy and management models for abandoned industrial areas. A case study in Yerevan 02011

Astghik Grigoryan, Zara Manvelyan and Emilya Sargsyan

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502011>

[Abstract](#) | [PDF \(2.355 MB\)](#) | [References](#)

---

Open Access

### Batik classification using KNN algorithm and GLCM features extraction 02012

David Wijaya and Anastasia Rita Widiarti

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502012>

[Abstract](#) | [PDF \(2.096 MB\)](#) | [References](#)

---

Open Access

### Environmental management for car accident precaution and remote notification 02013

Gerardo Reinaldy, Peter Rhatodirdjo Angka, Albert Gunadhi, Hartono Pranjoto, Yuliati and

Rasional Sitepu

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502013>

[Abstract](#) | [PDF \(3.176 MB\)](#) | [References](#)

---

Open Access

### Fall detection and notification system to fast emergency management for the elderly 02014

Ivan Goldwin, Albert Gunadhi, Diana Lestariningsih, Hartono Pranjoto, Peter Rhatodirdjo Angka and Lanny Agustine

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502014>

[Abstract](#) | [PDF \(2.601 MB\)](#) | [References](#)

---

Open Access

### Classification of delivery type of pregnant women using support vector machine 02015

Maria Yubela Chelsea and Paulina H. Prima Rosa

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502015>

[Abstract](#) | [PDF \(2.010 MB\)](#) | [References](#)

---

Open Access

### A study of stochastic epidemic model driven by liouville fractional brownian motion coupled with seasonal air pollution 02016

Herry Pribawanto Suryawan

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502016>

[Abstract](#) | [PDF \(1.844 MB\)](#) | [References](#)

---

Open Access

### Aerial object detection analysis: Challenges and preliminary results 02017

Agnes Maria Polina, Hari Suparwito and Rosalia Arum Kumalasanti

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502017>

[Abstract](#) | [PDF \(3.437 MB\)](#) | [References](#)

---

Open Access

### The performance of DST-Wavelet feature extraction for guitar chord recognition 02018

Linggo Sumarno

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447502018>

[Abstract](#) | [PDF \(1.979 MB\)](#) | [References](#)

## ***- Renewable Energy Technologies and Systems***

Open Access

An overview of wind energy to optimize initial potential in Java 03001

Ade Yurika Isti Megawati, Fairusy Fitria Haryani, Sukarmin, Sarwanto, Daru Wahyuningsih, Pujayanto and Supurwoko

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503001>

[Abstract](#) | [PDF \(2.201 MB\)](#) | [References](#)

---

Open Access

Numerical investigation on the effect of blunt body deflector on darieus turbine performance 03002

Ahmad Syafiq Rofi'i, Aditia Aulia, Muhammad Ferry Fadri, Muhammad Haidar Syarif, Elvira Rosmawati Rahman and Gunawan Dwi Haryadi

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503002>

[Abstract](#) | [PDF \(2.695 MB\)](#) | [References](#)

---

Open Access

Solar power control system on smart green home 03003

David Adhi Supriyanto Putra, Bernadeta Wuri Harini, Regina Chelinia Erianda Putri, Stefan Mardikus and Petrus Setyo Prabowo

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503003>

[Abstract](#) | [PDF \(2.780 MB\)](#) | [References](#)

---

Open Access

Using a stepper motor as a low-power, low-rotation DC generator for renewable energy harvesting 03004

Djoko Untoro Suwarno

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503004>

[Abstract](#) | [PDF \(2.053 MB\)](#) | [References](#)

---

Open Access

Design and implementation of 232.2 KWp rooftop on grid solar power plant 03005

Rasional Sitepu, Andrew Joewono, Yuliati, Peter R. Angka, Brian Teja, Hartono Pranjoto and Albert Gunadhi

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503005>

[Abstract](#) | [PDF \(2.289 MB\)](#) | [References](#)

---

Open Access

An experimental investigation on CCFL characteristics during gas/low surface tension liquid counter-current two-phase flow in a small-scaling PWR hot leg typical geometry 03006

Achilleus Hermawan Astyanto, Dede Rafico Saleh, Indarto and Deendarlianto

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503006>

[Abstract](#) | [PDF \(2.485 MB\)](#) | [References](#)

---

Open Access

Aerodynamic analysis of a windmill water pump using blade element momentum theory 03007

M.N. Setiawan, Harry Ramadhan, A. Michelle Sutopo and Zulkan

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503007>

[Abstract](#) | [PDF \(3.204 MB\)](#) | [References](#)

---

Open Access

Techno-economic analysis of hybrid PV-Battery-diesel system for isolated Dockyard In West Papua 03008

Azis Saputra, Aji Setyawan, Chairiman, Adinda Ihsani Putri and Lina Jaya Diguna

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503008>

[Abstract](#) | [PDF \(2.686 MB\)](#) | [References](#)

---

Open Access

Machine learning based modeling for estimating solar power generation 03009

Nur Uddin, Edi Purwanto and Hari Nugraha

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503009>

[Abstract](#) | [PDF \(3.011 MB\)](#) | [References](#)

---

Open Access

Coefficient of power of Indonesian traditional wind-pump blade model 03010

Albertus Naturally Baskoro, Y.B. Lukiyanto, Dionisius Brian Deva Erwandha and Rines Rines

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447503010>

[Abstract](#) | [PDF \(1.969 MB\)](#) | [References](#)

## ***- Sustainable Agriculture and Land Use Practices***

Open Access

Assessing the effectiveness of agricultural policies on development: A systematic literature review from diverse countries 04001

Tidiane Guindo and Muhamad Bai'ul Hak

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447504001>

[Abstract](#) | [PDF \(1.964 MB\)](#) | [References](#)

---

Open Access

Nutrition control in nutrient film technique hydroponic system using fuzzy method 04002

Augustinus B. Primawan and Novadi D.L. Kusuma

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447504002>

[Abstract](#) | [PDF \(2.528 MB\)](#) | [References](#)

---

Open Access

The inhibitive effect of vitamin B<sub>2</sub>, B<sub>6</sub> and vitamin C on the cooper corrosion 04003

Hartono Pranjoto, Adriana Anteng Anggorowati, Andrew Joewono, Lourentius Suratno and Adi Candra

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447504003>

[Abstract](#) | [PDF \(2.069 MB\)](#) | [References](#)

## ***- Waste Management and Recycling***

Open Access

Readiness assessment of lean six sigma implementation in the manufacturing industry as a way to ensure sustainability 05001

Fransisca Candra Dewi, Lusia Permata Sari Hartanti, Dian Retno Sari Dewi, Julius Mulyono and Ig. Jaka Mulyana

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447505001>

[Abstract](#) | [PDF \(1.993 MB\)](#) | [References](#)

---

Open Access

**Modeling study of boiler using oil waste as an energy source** 05002

Stefanus Suprianto, Tjendro, Martanto and Bernadeta Wuri Harini

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447505002>

[Abstract](#) | [PDF \(2.980 MB\)](#) | [References](#)

---

Open Access

**Utilization of used oil waste for boiler energy source** 05003

Akbar Pribadi, Theresia Prima Ari Setiyani, Tjendro, Budi Setyahandana and Martanto

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447505003>

[Abstract](#) | [PDF \(3.536 MB\)](#) | [References](#)

---

Open Access

**SCADA for waste sorting system as an environmental conservation effort** 05004

Thomas Eryanto Loblobly, Ridowati Gunawan, Haris Sriwindono and Theresia Prima Ari Setiyani

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447505004>

[Abstract](#) | [PDF \(4.504 MB\)](#) | [References](#)

---

Open Access

**Antibacterial properties of enzymatically treated PET fibers functionalized by nitric oxide** 05005

Nathania Puspitasari, Cheng-Kang Lee and Chia-Tzu Liu

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447505005>

[Abstract](#) | [PDF \(2.154 MB\)](#) | [References](#)

---

Open Access

**Optimization of pyrolysis of polypropylene and polyethylene based plastic waste become an alternative oil fuel using bentonite catalyst** 05006

Eunike Desnia, Edwand Rosie, Sandy Budi Hartono, Wiyanti Fransisca Simanullang, Adriana Anteng Anggorowati and Suratno Lourentius

Published online: 08 January 2024

DOI: <https://doi.org/10.1051/e3sconf/202447505006>

---

## E3S Web of Conferences

eISSN: 2267-1242



[Mentions légales](#)

[Contacts](#)

[Privacy policy](#)

*A Vision4Press website*

# A study of stochastic epidemic model driven by liouville fractional brownian motion coupled with seasonal air pollution

Herry Pribawanto Suryawan<sup>1\*</sup>

<sup>1</sup>Department of Mathematics, Faculty of Science and Technology, Sanata Dharma University, Yogyakarta, Indonesia

**Abstract.** Air pollution can cause and provoke respiratory diseases. It is an important topic to the public, particularly in developing countries. Since there are many uncertain factors in the environment, stochastic differential equation model is a powerful tool to study the changes of air pollution and the transmission of infectious diseases. The removal of air pollutants as well as the transmission of diseases can be influenced by random perturbations with memories. In this research, we develop a mathematical model in the form of a system of stochastic differential equations driven by fractional Brownian motion of Liouville-type, coupled with seasonal air pollution, to study the dynamics of infectious respiratory disease spread. As a result, by using stochastic calculus techniques, we derive the equation for the level of air pollution.

## 1 Introduction

Air pollution has aroused a great concern all over the world, because it can cause and aggravate respiratory diseases, see e.g. [1]. According to Alyousifi et al in [2] the level of air pollution reaches epidemic levels, which is caused by increasing use of fossil fuels, increasing vehicle exhaust emissions, the excessive industrialization and the destruction of vegetation. Numerous epidemiological studies have shown associations of particulate air pollution with risk for various adverse health outcomes, in which the most affected pathologies are chronic obstructive pulmonary disease, lung cancer, influenza and respiratory infectious diseases, see, for instances [3-5]. Hence, it is important to have a comprehensive understanding through mathematical means of the change of air pollution, and to evaluate the effects of air pollution on people's health. Since there are many random factors in the environment as mentioned in [6, 7], stochastic differential equation (SDE) model is a useful tool to study the changes of air pollution and the transmission of infectious diseases [8, 9].

The air quality index (AQI) is commonly used as a standard measurement of air quality in a quantitative description. Human activities are the main sources of air pollution and lead to atmospheric contamination with a wide variety of pollutants such as fine particulate matter, inhalable particles, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide [10]. However, some pollutants may be cleared by vegetation or dispersed by wind. Some studies,

---

\* Corresponding author: [herrypribs@usd.ac.id](mailto:herrypribs@usd.ac.id)



such as in [11, 12], show that high concentrations of air pollutants have a positive association with respiratory symptoms or hospitalization. Chung et al. in [13] showed that hospital admissions due to chronic obstructive pulmonary disease (COPD) and the increase in asthma prevalence were associated with the level of outdoor air pollutants. In particular, some epidemiological and experimental studies indicated an increased risk for respiratory viral infections, see e.g. [14]. To study the impact of seasonal changes in air pollution and random factors in the environment on infectious respiratory diseases, He et al in 2019 developed a stochastic susceptible-infective-susceptible (SIS) model driven by random change of air pollution, see [15]. This model has two features:

1. the equations of the value of AQI, denoted by  $F(t)$ , and the number of infectives, denoted by  $I(t)$ , are both time-inhomogeneous, i.e., the coefficients in the equations are constants.
2. the removal process of air pollution is disturbed by some random factors.

In reality, the periodic phenomenon in air pollution is widely observed in time series data under varying climatic and environment conditions as studied in [16, 17]. Therefore, it would be more realistic to assume the coefficients in the equation describing  $F(t)$  to be periodic functions rather than constants. Deepa et al in [18] proved that there is a linear correlation between particulate matter and respiratory disease. The risk of respiratory diseases is related to the severity of air pollution. When we study the dynamics of respiratory diseases, the infection probability of infectious respiratory diseases is positively correlated with the value of AQI. In order to describe this, we assume that the transmission rate of the disease is a function dependent on the AQI.

In addition to seasonal changes, random disorder can also affect the disease dynamics, see, for instances, [19-21]. Therefore, it is necessary to consider randomness in the change of air pollution and respiratory disease transmission. He et al in [22] continued their study by assuming that both the clearance process of air pollution and the infection of disease are subject to random disturbance. Although there are many studies of periodic SDE and periodic stochastic epidemic models, such as in [23-26], there is a lack of the analysis for mathematical model that couples seasonal variations in air pollution with the dynamics of respiratory infections. The dynamical behavior of the air pollutant concentration is an inflow-clearance process and the equation of the change of AQI is independent of infection. However, the change of AQI affects the risk of infection of respiratory diseases. Thus, the periodicity of the whole system is caused by the periodicity of one equation. It is not trivial to analyze the full coupled system directly. Therefore, mathematical analysis of such stochastic periodic models needs to be investigated.

Motivated by the work of He et al in [22], in the present study we generalize the model by replacing the noise source from standard Brownian motion to Liouville fractional Brownian motion to capture the long memory property in the reality. The main section in the paper is organized as follows. First, we summarize a theoretical background on the Liouville fractional Brownian motion. Next, we build the epidemic model driven by Liouville fractional Brownian motion coupled with seasonal air pollution. Finally, since the level of air pollution in the model is independent of the number of infectious individuals, we start with a derivation of a solution of the stochastic equation on the air pollution level by using the stochastic calculus with respect to Liouville fractional Brownian motion developed via semimartingale approximation.

## 2 Model and analysis

### 2.1 Liouville fractional Brownian Motion

The fractional Brownian motion (fBm) of Hurst parameter  $H \in (0,1)$  is a centered Gaussian process  $B^H = (B_t^H)_{t \geq 0}$  defined on some probability space  $(\Omega, \mathcal{F}, \mathbb{P})$  with the covariance function

$$\text{cov}(t, s) = \mathbb{E}(B_t^H B_s^H) = \frac{1}{2}(t^{2H} + s^{2H} - |t - s|^{2H})$$

This stochastic process is introduced by A.N. Kolmogorov in the 1940's and is the only Gaussian self-similar process with stationary increments. The fBm has attracted many attentions due to its wide range of applications such as in mathematical finance, hydrology, filtering theory, and queuing networks. In the case where  $H = \frac{1}{2}$ , the process  $B^H$  is a standard Brownian motion. If  $H \neq \frac{1}{2}$ ,  $B^H$  is neither a semimartingale nor a Markov process and the classical Ito stochastic calculus cannot be applied. There are various approaches to stochastic calculus with respect to fBm by using some difficult tools such as: regularization approach [27], Malliavin calculus [28], theory of Wick product [29], pathwise approach [30], and white noise analysis [31]. However, it is not easy to find explicit solutions from these methods for many practical problems.

Mandelbrot and van Ness in [32] proved a stochastic integral representation of fBm in the form:

$$B_t^H = \frac{1}{\Gamma(H + \frac{1}{2})}(U_t + W_t^H),$$

where  $(U_t)_{t \geq 0}$  is a stochastic process of absolutely continuous trajectories and  $W^H = (W_t^H)_{t \geq 0}$  with

$$W_t^H := \int_0^t (t-s)^{H-\frac{1}{2}} dB_s$$

is called a Liouville fractional Brownian motion (LfBm). Here,  $(B_t)_{t \geq 0}$  is a standard Brownian motion and  $\Gamma$  is the Euler gamma function. Note that for  $H = \frac{1}{2}$ ,  $W_t^H = B_t$ . An LfBm shares many properties of a fBm, such as Holder continuity of trajectories and long-range dependence, except that it has non-stationary increments. For a more detailed discussion see e.g. [33]. Moreover, Comte and Renault in [34] gave a nice application of LfBm to finance. Because of these reasons and for simplicity we use  $W^H$  throughout this paper. It is known that  $W_t^H$  can be approximated in  $L^2(\Omega)$  by semimartingale  $(M_t^\varepsilon)_{t \geq 0}$ ,  $\varepsilon > 0$  with

$$M_t^\varepsilon = \int_0^t (t-s+\varepsilon)^{H-\frac{1}{2}} dB_s,$$

and the convergence is uniform in  $t \in [0, T]$ . Stochastic calculus with respect to LfBm via semimartingale approximation was first introduced by Thao in [35] and then further investigated by Dung, see [36-38]. In particular, the SDE of the form

$$dX_t = b(t, X_t)dt + \sigma(t)X_t dW_t^H, \quad X_0 = x_0 \quad (1)$$

is studied in [38]. In order to guarantee the existence and uniqueness of the solution of Eq. (1), the following standard assumptions on coefficients are made. The volatility  $\sigma: [0, T] \rightarrow \mathbb{R}$  is a bounded deterministic function and the drift coefficient  $b: [0, T] \times \mathbb{R} \rightarrow \mathbb{R}$  is a measurable function in all their arguments and satisfies the following conditions: there is a positive constant  $K$  such that

- 1)  $b(t, x)$  is a continuously differentiable function in  $x$  and  $|b(t, x) - b(t, y)| \leq K|x - y|$  for all  $x, y \in \mathbb{R}$ ,  $t \in [0, T]$ , and

$$2) |b(t, x)| \leq K (1 + |x|) \text{ for all } x \in \mathbb{R}, t \in [0, T].$$

**Theorem 2.1** ([38, Theorem 3.2])

SDE (1) has a solution which is given by

$$X_t = Y_t^{-1}Z_t,$$

where

$$Y_t = \exp\left(-\int_0^t \sigma(s)dW_s^H\right)$$

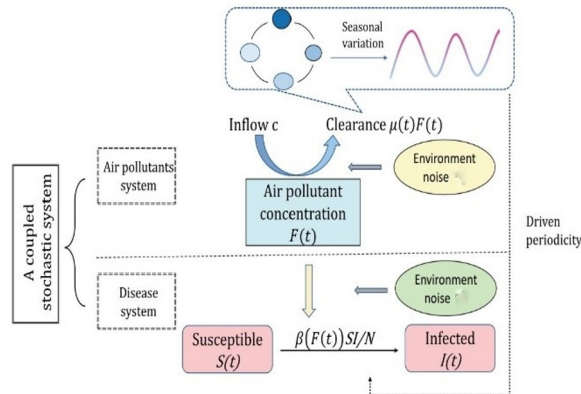
and  $Z_t$  is the unique solution of the random differential equation

$$dZ_t = Y_t b(t, Y_t^{-1}Z_t) dt, \quad Z_0 = x_0.$$

Note that the stochastic integral in  $Y_t$  is well-defined as an  $L^2(\Omega)$ -limit of a sequence of stochastic integrals with respect to semimartingale.

**2.2 The model**

In the study of infectious respiratory disease dynamics affected by air pollution, an Susceptible-Infectious System (SIS) model is used to describe the dynamic behavior of epidemics, where  $S(t)$  and  $I(t)$  denote the number of susceptible and infectious individuals at time  $t$ , respectively. The total population is assumed to be a constant  $N$ . The number of susceptible individuals can be represented by  $N - I(t)$ . Let  $\beta(t)$  be the disease transmission rate function. The severity of air pollution affects the infectious respiratory disease transmission rate. Thus, we assume that the disease transmission rate  $\beta(t)$  depends on the level of air pollution, denoted as  $F(t)$ . It is assumed to be a function of  $F(t)$ . This is the rate at which susceptibles come into  $\beta(F(t))$  potentially infectious contact with infected individuals, which changes with the value of  $F(t)$ . In our model, the relationship is further assumed to be linear, i.e.  $\beta(F(t)) = \beta F(t)$ . To incorporate the seasonality in the variation of air pollutants, the clearance rate, denoted by  $\mu(t)$ , is assumed to change over time with a certain period. The inflow rate of pollutants is assumed to be a constant  $c$ . As mentioned in the introduction, the dynamics of the concentration of pollutants and infected individuals are stochastic. The diagram of the model is shown in Fig. 1.



**Fig. 1.** Flow diagram of the coupled system [22].

In the model, we consider the situation in which both the disease transmission rate  $\beta(t)$  and the clearance rate of air pollutants  $\mu(t)$  are influenced by random perturbations. Thus, we replace  $\beta(F(t))$  by  $\beta(F(t)) + \sigma_1\eta_1(t)$  and  $\mu(t)$  by  $\mu(t) + \sigma_2\eta_2(t)$ , where  $\eta_1(t)$  and

$\eta_2(t)$  are Liouville fractional white noises (the time derivative of LfBm in the sense of generalized function),  $\sigma_1$  and  $\sigma_2$  are two nonnegative real numbers, which represent the intensities of noises  $\eta_1(t)$  and  $\eta_2(t)$ , respectively. Modifying the model in the [22], the seasonally forced stochastic model driven by LfBm can be written as

$$\begin{cases} dI(t) = \left( \beta F(t) \frac{(N - I(t))I(t)}{N} - \gamma I(t) \right) dt \\ \quad + \sigma_1 \frac{(N - I(t))I(t)}{N} dW_1^H(t) \\ dF(t) = (c - \mu(t)F(t)) dt - \sigma_2 F(t) dW_2^H(t) \end{cases} \quad (2)$$

Here,  $W_1^H$  dan  $W_2^H$  are independent LfBms,  $\beta F(t)$  is the infection rate, and  $\gamma > 0$  is the recovery rate for infected individuals. In this paper, we choose the pollution clearance rate  $\mu(t)$  to be

$$\mu(t) = \mu_0 + \mu_1 \sin(\omega t + \phi), \quad (3)$$

where  $\omega = \frac{2\pi}{365}$  is a periodic parameter assuming that there are 365 days in a year,  $\phi$  and  $\mu_0$  are the phase parameter and offset parameter, respectively. The amplitude is controlled by  $\mu_1$ . It is clear that  $\mu_0 - \mu_1 \leq \mu(t) \leq \mu_0 + \mu_1$ .

### 2.3 Analysis of the model

In model (2), the second equation of  $F(t)$  is independent of the first equation of  $I(t)$ . The explicit solution of  $F(t)$  can be obtained using Theorem 2.1 as follows. Let  $Y_t = \exp\left(-\int_0^t \sigma_2 dW_s^H\right) = \exp(-\sigma_2 W_t^H)$ . The solution  $F(t)$  is given by  $F(t) = Y_t^{-1} Z_t$ , where  $Z_t$  is the unique solution of the random differential equation

$$dZ_t = Y_t(c - \mu(t)Y_t^{-1}Z_t),$$

where  $\mu(t)$  is given by (3). Hence,

$$\begin{aligned} dZ_t &= \exp(-\sigma_2 W_t^H) (c - \mu(t) \exp(\sigma_2 W_t^H) Z_t) \\ &= c \exp(-\sigma_2 W_t^H) - \mu(t) Z_t. \end{aligned}$$

Rewriting the last expression, we obtain a nonhomogeneous linear first order random differential equation

$$\frac{dZ_t}{dt} + \mu(t)Z_t = c \exp(-\sigma_2 W_t^H), Z_0 = F(0) = F_0 \quad (4)$$

Let us use the integrating factor

$$\begin{aligned} &\exp\left(\int \mu(t) dt\right) \\ &= \exp\left(\int (\mu_0 + \mu_1 \sin(\omega t + \phi)) dt\right) \\ &= \exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi)\right). \end{aligned}$$

Then, multiply both sides of (4) by the integrating factor to obtain

$$\begin{aligned} &\exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi)\right) \left(\frac{dZ_t}{dt} + \mu(t)Z_t\right) \\ &= c \exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi)\right) \exp(-\sigma_2 W_t^H). \end{aligned}$$

The last equation is equivalent with

$$\frac{d}{dt} \left( \exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi)\right) Z_t \right)$$

$$= c \exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi) - \sigma_2 W_t^H\right).$$

Integrating from 0 to  $t$  gives

$$\begin{aligned} & \int_0^t \frac{d}{ds} \exp\left(\mu_0 s - \frac{\mu_1}{\omega} \cos(\omega s + \phi)\right) Z_s ds \\ &= \int_0^t c \exp\left(\mu_0 s - \frac{\mu_1}{\omega} \cos(\omega s + \phi) - \sigma_2 W_s^H\right) ds. \end{aligned}$$

Applying the fundamental theorem of calculus we get

$$\begin{aligned} & \exp\left(\mu_0 s - \frac{\mu_1}{\omega} \cos(\omega s + \phi)\right) Z_s \Big|_0^t \\ &= c \int_0^t \exp\left(\mu_0 s - \frac{\mu_1}{\omega} \cos(\omega s + \phi) - \sigma_2 W_s^H\right) ds \end{aligned}$$

and hence

$$\begin{aligned} & \exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi)\right) Z_t \\ &= \exp\left(-\frac{\mu_1}{\omega} \cos \phi\right) F_0 \\ & \quad + c \int_0^t \exp\left(\mu_0 s - \frac{\mu_1}{\omega} \cos(\omega s + \phi) - \sigma_2 W_s^H\right) ds. \end{aligned}$$

By dividing both sides with  $\exp\left(\mu_0 t - \frac{\mu_1}{\omega} \cos(\omega t + \phi)\right)$  and simplifying the result gives the solution of (4):

$$\begin{aligned} Z_t &= F_0 \exp\left(-\mu_0 t + \frac{\mu_1}{\omega} \cos(\omega t + \phi) - \frac{\mu_1}{\omega} \cos \phi\right) \\ & \quad + c \int_0^t \exp\left(-\mu_0(t-s) - \sigma_2 W_s^H\right) \\ & \quad \exp\left(\frac{\mu_1}{\omega} \cos(\omega t + \phi) - \cos(\omega s + \phi)\right) ds. \end{aligned}$$

Now,

$$\begin{aligned} F(t) &= Y_t^{-1} Z_t \\ &= \exp(\sigma_2 W_t^H) Z_t \\ &= F_0 \exp\left(-\mu_0 t + \frac{\mu_1}{\omega} (\cos(\omega t + \phi) - \cos \phi) + \sigma_2 W_t^H\right) + c \int_0^t \exp\left(-\mu_0(t-s) + \right. \\ & \quad \left. \sigma_2 (W_t^H - W_s^H) + \frac{\mu_1}{\omega} (\cos(\omega t + \phi) - \cos(\omega s + \phi))\right) ds. \quad (5) \end{aligned}$$

Observe that the solution (5) is complicated and hence, cannot be directly substituted into the first equation of model (2) for a further theoretical analysis. This makes it difficult to obtain the properties of the equation of  $I(t)$ . In view of this obstacle, one should first study some properties of  $F(t)$  in model (2).

### 3 Conclusion

This preliminary study introduces a coupled periodic SDE model driven by LfBm to study the dynamics of infectious respiratory disease in an environment with air pollution. We assume that the clearance process of air pollutant has seasonal variation and random disturbance. In addition, the transmission rate of the disease is assumed to depend on the concentration of air pollutants and also has random disturbance. The connection between the air pollutants and the number of infected individuals is that the change of concentration of air pollutants is independent of the disease infection of human but affects the the

susceptibility to infection. It is mathematically challenging to analyze this coupled stochastic system by exact methods. So far, we are able to give analytical solution for  $F(t)$ . Unfortunately, this analytical solution of  $F(t)$  is intricate and cannot be directly used in the equation of  $I(t)$  for further analysis. For future research we plan to do a more deep study on  $F(t)$  such as investigation of its boundedness and the existence of periodic solutions. It is also planned to verify the theoretical results by numerical experiments. To see that our model whether suitable for studying infectious respiratory diseases whose transmission can be investigated by an SIS epidemiological model we should validate the model and estimate parameter values by data fitting. This will be also considered in a forthcoming work.

## References

1. M. Fernandes, C. Carletti, L. Sierra de Araujo, R. Santo, J. Reis, *Rev. Neurol* **175**, 10 (2019)
2. Y. Alyousifi, N. Masseran, K. Ibrahim, *Stoch. Env. Res. Risk.* **32**, (2018)
3. C. A. Pope, R.T. Burnett, M. J. Thun, E. E. Calle, D. Krewski, K. Ito, G. D. Thurston, *JAMA* **287**, 9 (2002).
4. P. M. Manucci, *Europ. Heart J.* **34**, 17 (2013)
5. G. P. Bala, R. M. Rajnoveanu, E. Tudorache, R. Motisan, C. Oancea, *Environ. Sci. Pollut. Res. Int.* **28**, 16 (2021)
6. F. Benth, J. Saltyte-Benth, *Appl. Math. Financ* **12**, 1 (2005)
7. X. Dong, X. Zhao, F. Peng, D. Wang, *Sci. Rep.* **10**, 1 (2020)
8. S. Jha, C. Langmead, *Exploring behaviors of SDE models of biological systems using change of measures*, in IEEE International Conference on Computational Advances in Bio and Medical Sciences (2011)
9. S. Makhno, S. Melnik, *J. Math. Sci.* **231**, 1 (2018)
10. S. Nagendra, V. K. Shiva, S. L. Jones, *Transp. Res. D. Transp. Environ.* **12**, 3 (2007)
11. A. Petroschevsky, R. W. Simpson, L. Thalib, S. Rutherford, *Arch. Environ. Health* **56**, 1 (2001)
12. J. Sun, N. Zhang, M. Wang, J. Wang, *Stoch. Environ. Res. Risk.* **34**, (2020)
13. K. F. Chung, J. Zhang, N. Zhong, *Respirology* **16**, 7 (2011)
14. F. J. Kelly, *EMJ Respir.* **2**, (2014)
15. S. He, S. Tang, W. Wang, *Phys. A* **532**, (2019)
16. A. Augustaitis, I. Augustaitiene, A. Kliucius, G. Pivoras, D. Sopauskiene, R. Girgzdiene, *Eur. J. Forest Res.* **129**, 3 (2010)
17. G. Touloumi, E. Samoli, A. Le-Tertre, R. Atkinson, K. Katsouyanni, *Stat. Med.* **25**, 24 (2010)
18. M. Deepa, M. Rajalakshmi, R. Nedunchezian, *Data-Enabled Discov. Appl.* **1**, 1 (2017)
19. I. Cattadori, A. Pathak, M. Ferrari, *Ecol. Evol.* **9**, 23 (2019)
20. W. Ma, G. Lin, J. Liang, *Ecol. Model.* **419**, 1 (2020)
21. W. Wang, C. Ji, J. Bi, S. Liu, *Appl. Math. Lett.* **104**, (2020)
22. S. He, S. Tang, Y. Cai, W. Wang, L. Rong, *Stoch. Environ. Res. Risk.* **34**, (2020)
23. Y. Cai, Y. Kang, M. Banerjee, W. Wang, *J. Differ. Equ.* **259**, 12 (2015)
24. S. He, S. Banerjee, *Phys. A* **501**, (2018)

25. W. Zhao, J. Liu, M. Chi, F. Bian, *Adv. Differ. Equ.* **2019**, 1 (2019)
26. B. Yang, Y. Cai, K. Wang, W. Wang, *Phys. A* **526**, (2019)
27. F. Russo, P. Vallois, *Probab. Th. Rel. Fields* **97**, 3 (1993)
28. E. Alòs, O. Mazet, D. Nualart, *Annals Prob.* **29**, 2 (2001)
29. T. Duncan, B. Pasic-Duncan, Y. Hu, *Stochastic calculus for fractional Brownian motion I. Theory*, in Proceedings of the IEEE Conference on Decision and Control 38 (2), (2000)
30. S.J. Lin, *SIAM Review* **10**, (1995)
31. C. Bender, *Stochastic Process. Appl.* **104**, (2003)
32. B. Mandelbrot, J. W. van Ness, *SIAM Review* **10**, (1968)
33. S. C. Lim, *J. Phys. A: Math. Gen.* **34**, (2001)
34. F. Comte, E. Renault, *Math. Finance* **8**, 4 (1998)
35. T. H. Thao, *Nonlinear Anal.* **7**, (2006)
36. N. T. Dung, *Vietnam J. Math.* **36**, 3(2008)
37. N. T. Dung, *Comput. Math. with Appl.* **61**, 7 (2011)
38. N. T. Dung, *J. Math. Anal. Appl.* **397**, (2013)