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Table of contents

Volume 819

2021

[◀ Previous issue](#) [Next issue ▶](#)

2nd International Conference Earth Science And Energy 11 November 2020, Kuala Lumpur, Malaysia

Accepted papers received: 02 July 2021

Published online: 14 July 2021

[Open all abstracts](#)

Preface

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011001

Preface

[+ Open abstract](#)[View article](#)[PDF](#)

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011002

Peer review declaration

[+ Open abstract](#)[View article](#)[PDF](#)

Agriculture

OPEN ACCESS

012001

[Ganoderma boninense control in palm oil plantations using *Trichoderma harzianum* in various Media](#)

Aries Sukariawan, Eka Bobby Febrianto, Sakiah, Muhammad Ridho and Doli Karnando

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012002

[Preparation and characterization of cellulose microcrystalline made from palm oil midrib](#)

Pada Mulia Raja, Ika Ucha P. Rangkuti, M. Hendra Ginting, Giyanto and Wahyu F. Siregar

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS 012003
The study of soil biological and chemical properties on palm oil plant rhizosphere with and without palm oil mill effluent applications

Megawati Siahaan, Sakiah, Arief S Sutanto, A Lawary and R Mahmuda

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012004
Evaluation of the Value of the Defective and Taste of Arabica Coffee (*Coffea Arabica L*) West Sumatera

Rince Alfia Fadri, K Kesuma Sayuti, Novizar Nazir and Irfan Suliansyah

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012005
Utilization of alternative ingredients as combination feed on the growth of catfish (*Clarias sp.*)

RC Mukti, M Amin and Yulisman

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012006
Assessment on shallot farming development in North Padang Lawas Regency, North Sumatra

Moral Abadi Girsang, Palmarum Nainggolan, Shabil Hidayat, Suheri Sitepu and Khadijah El Ramija

[+ Open abstract](#) [View article](#) [PDF](#)

Agrotechnology

OPEN ACCESS 012007
Application of Trichoderma as an Alternative to the use of Sulfuric Acid Pesticides in the Control of Diplodia Disease on Pomelo Citrus

Mei Silvia and Sutarman

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012008
The Effect of Trichoderma and Onion Extract on the Success of Grafting in Mango Seedlings

Feroniza Berlian Sentosa, Sutarman and Intan Rahma Nurmalasari

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012009
Isolation and Performance Testing of *Bacillus subtilis* As Biological Agents to Control the Diplodia Disease on Siam Citrus

Dinda Aprilia, Agus Miftakhurohmat and Sutarman

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012010
K-Nearest Neighbor Algorithm to Identify Cucumber Maturity with Extraction of One-Order Statistical Features and Gray-Level Co-Occurrence

Syamsudduha Syahroringi, Denny Syamsudin, Dwi Hadidjaja Rasjid Saputra and Akhmad Ahfas

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012011
Determination of Volatile Compounds on Traditional Fermentation of *Chao Teri*

Syahriati, UA Nur Fitriani and Muhammad Yusuf

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012012

Physicochemical, nutritional, and color characteristic of Nori Snack from Snakehead Fish (*Ophiocephalus striatus*), *Eucheuma cottonii*, and *Gracilaria sp*

Muhammad Yusuf, UA Nur Fitriani and Syahriati

[+ Open abstract](#) [View article](#) [PDF](#)

Animal Science

OPEN ACCESS

012013

Reproductive characters of hampala fish (*hampala macrolepidota kuhl & Van Hasselt, 1823*), correlation with body length

Suhestri Suryaningsih, Sri Sukmaningrum, Adi Amurwanto and Aswi Andriasari Rofiqoh

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012014

Efficacy of application time of *Penicillium sp.* suspension on White Root Fungus (*Rigidoporus lignosus*) in Nutmeg (*Myristica fragrans*)

Chairudin, Agustinur and J Permadi

[+ Open abstract](#) [View article](#) [PDF](#)

Aquatic Resource Management

OPEN ACCESS

012015

The correlation between mangrove ecosystem with shoreline change in Indramayu coast

Sofyan Hasanuddin Nur and Endang Hilmi

[+ Open abstract](#) [View article](#) [PDF](#)

Earth and Energy Science

OPEN ACCESS

012016

Microbial fuel cell based biocatalyst from traditional market waste water for energy production

Ummi Mardiana

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012017

Sugarcane bagasse for environmentally friendly super-absorbent polymer: synthesis methods and potential applications in oil industry

Shabrina Sri Riswati, Rini Setiati, Sugiatmo Kasmungin, Suryo Prakoso and Muhammad Taufiq Fathaddin

[+ Open abstract](#) [View article](#) [PDF](#)

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012018

Lithofacies Association of Fluvial Deposit, Walat Formation in Cibadak Area West Java

S D Hafiz, H Firman, A Ramadhan and W T Koesmawardhani

[+ Open abstract](#) [View article](#) [PDF](#)

-
- OPEN ACCESS** 012019
Geothermal Well Targeting in Consideration To Geological Structures of Mataloko Field, Flores
Untung Sumotarto, Yudistian Yunis, Fajar Hendrasto, Kris Pudyastuti, Evan R. Sammuel, Dhany Rizky and Arthur G.P. Nayoan
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012020
New Insight of Surface and Subsurface Sedimentology of Salodik Group, Banggai Basin
Firman Herdiansyah, M Burhannudinnur, M Ali Jambak and Teddy Irano
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012021
Petrophysical Analysis to Determine the Initial Oil Reserves in the AHP Field
Apolonius Harda Putranta Sudi, Ratnayu Sitaresmi and Prayang Sunny Yulia
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012022
Compatibility Test for Screening Surfactant Flooding
M Dhafa, R Setiati, M T Malinda and A Anugrahadi
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012023
The Opportunities and Constraints of Wind Energy
A A S Siahaya, R Setiati and M T Malinda
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012024
Effect of Improvement of Temperature and Gas Amount on Nitrogen Flooding
M T Malinda, R Setiati, M A Azizi and Y F Simbolon
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012025
Laboratory Study: The Effect of Clay Mineral in Sandstone on Resistivity of Rock
Ratnayu Sitaresmi, Rosidelly, Lia Mega and M. Taufiq Fathaddin
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012026
Drill Holes Spacing Analysis for Estimation and Classification of Coal Resources Based on Variogram and Kriging
M D Ramadhan, I Marwanza, C Nas, M A Azizi, W Dahani and R Kurniawati
[+ Open abstract](#) [View article](#) [PDF](#)

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012027

The Palu Earthquake Formed a New Geological Structure

A. Anugrahadi, U. Sumarto and T. T. Punwiyono

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Energy

OPEN ACCESS

012028

Solar Energy Hybrid Control System Design Photovoltaic Using Fuzzy Logic Controller

Ramadan Salem Ramadan

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012029

Analysis of Overcurrent Safety in Miniature Circuit Breaker AC (*Alternating Current*) and DC (*Direct Current*) in Solar Power Generation Systems

Jamaaluddin Jamaaluddin, Indah Sulistiyowati, BWA. Reynanda and Izza Anshory

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012030

The Application of Geostatistical Analysis on Radiometric Mapping Data to Recognized the Uranium and Thorium Anomaly in West Sulawesi, Indonesia.

I Gde Sukadana, I Wayan Warmada, Agung Harjoko, Frederikus Dian Indrastomo and Heri Syaeful

[+ Open abstract](#) [View article](#) [PDF](#)

Environmental Issue

OPEN ACCESS

012031

Causes, Dynamics, and Environmental Conflict Resolution Models in Coal-Fired Steam Power Plant Development Locations

Ria Ishardanti, Herdis Herdiansyah and Francisia Saveria Sika Ery Seda

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012032

Illegal artisanal and small-scale mining practices: re-thinking the harm

Putu P. S. Agustina, Herdis Herdiansyah and Anggi A. Harahap

[+ Open abstract](#) [View article](#) [PDF](#)

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012033

Good Governance Role for a Sustainable Solid Waste Management in Rural Community

Ari Naldi, Herdis Herdiansyah and L G Saraswati Putri

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OPEN ACCESS

012034

Climate Village Program for Climate Change Adaptation and Mitigation for Green Villages

Herdis Herdiansyah

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS 012035

Sustainable Development on Indonesian Environmental Risk Assessment

Agastyo Djanardono Basoeki, Herdis Herdiansyah and Yuki M. Adhitya Wardhana

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OPEN ACCESS 012036

Soybean production response: A study of Jambi's acreage response under policy program

Edison and Dharia Renate

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OPEN ACCESS 012037

Contribution of Oil Palm Plantation to Household in Kolaka District of Southeast Sulawesi

Haji Saediman, Rahmayana Rahmayana, Yusna Indarsyih, Nuryamin Budi and Lukman Yunus

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OPEN ACCESS 012038

The Development of Communication Model for the Empowerment of Highly Poor Villages in Pangandaran Regency, West Java, Indonesia

Y Yustikasari, I Gemiharto and F Ayuningtyas

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OPEN ACCESS 012039

Managing the uncertainty during COVID-19 pandemic: Communicating disaster and food industry sustainability

Myra V. de Leon, Daniel Susilo, Teguh Dwi Putranto, Fadjar Kurnia Hartati and Roberto Rudolf T. Santos

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OPEN ACCESS 012040

MRT as an Alternative Transportation Solution which is environmentally friendly and traffic jam free in Jakarta

Elfrida Ratnawati

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OPEN ACCESS 012041

Social-Ecological Vulnerability and Livelihood Improvement Strategies of Landslide Victims in Pattaliking Village, Gowa Regency in National Security Perspective

Khairunnisa Adri, Siswo Hadi Sumantri, Sugeng Triutomo and Deffi Ayu Puspito Sari

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OPEN ACCESS 012042

Determination of priority locations for the implementation of rice farming insurance: a case study on disaster hazards in Cilacap regency

Unggul Pramukti, Suryanto and Evi Gravitiani

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OPEN ACCESS

012043

Smallholder adoption of horticultural crops: the case of dragon fruit in Southeast Sulawesi

Haji Saediman, Ilham Saediman Mboe, Budiyanto Budiyanto, Sarinah Sarinah and Hidrawati Hidrawati

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Environmental Policy

OPEN ACCESS

012044

The government policy on the covid-19 handling viewed from environmental and biodiversity perspectives

Suwari Akhmaddhian, Toto Supartono, Erga Yuhandra, Haris Budiman and Diding Rahmat

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Environmental Science

OPEN ACCESS

012045

Fish diversity monitoring in Maninjau Lake, West Sumatra using the eDNA with the next generation sequencing (NGS) technique

D I Roesma, D H Tjong, M N Janra and D R Aidil

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OPEN ACCESS

012046

Protecting Biodiversity: The Importance of Understanding the Role of Government and Society in Human-Urban Wildlife Interaction in Indonesia

Peni Puspitasari, Herdis Herdiansyah and Donna Asteria

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OPEN ACCESS

012047

The effect of maggots lentera flies (*hermetia illucens*) growing media as the solution of using organic waste

Nina Herlina, Nurdin, Bambang Yudayana, ling Nasihin and Ai Nurlaila

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012048

Habitat characteristics and population of *leptophryne javanica* in Curug Cisurian, Kopi Bojong, and Ciinjuk in Gunung Ciremai National Park

Ika Karyaningsih, Nurdin, W Indra, Nina Herlina and Ai Nurlaila

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012049

Structure and similarities of Understorey Vegetation Communities in the mining area of PT. Indocement Tungal Prakarsa Tbk. Palimanan Unit, Cirebon

ling Nasihin, Dede Kosasih, Nina Herlina and Ai Nurlaila

[+ Open abstract](#) [View article](#) [PDF](#)

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012050

Dynamics of dengue hemorrhagic fever incidence and climate as potential factors in Palembang 2013 – 2019

Krisna Delita, Nurhayati Damiri, Rico Januar Sitorus, Poeji Loekitowati Hariani, Fika Minata Wathan and H Annisa Tassia

[+ Open abstract](#) [View article](#) [PDF](#)

Food Science

OPEN ACCESS

012051

The distillation process of palm sap (*Arenga pinnata* MERR) to produce bioethanol

Ansar, Nazaruddin and Atri Dewi Azis

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012052

Quality of Fermented Purple Sweet Potato (*Ipomea batatas* var. *Ayamurasaki*) (Tapai) in Various Yeast Concentration and Steaming Time

R Azara, L Qur'aini, I A Saidi, L Hudı, S R Nurbaya and R U Budiandari

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012053

Characteristics of Dry Carrot Noodle (*Daucus carota* L) with Proportion of Wheat Flour and White Oyster Mushroom Flour (*Pleurotus ostreatus*)

L Hudı, I A Saidi, R Azara and T R Pratiwi

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012054

Determination of Level of Lead (Pb) and Cadmium (Cd) Migration on Bowl and Clear Plastic Cup Using Atomic Absorption Spectrophotometer

Hurip Budi Riyanti and Y Yeni

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012055

Optimization and Validation Methods for Assay of Acyclovir Cream Determination by High Performance Liquid Chromatography

Muhamad Zaenudin, Almawati Situmorang and S Supandi

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OPEN ACCESS

012056

Total Flavonoids Content of Polar Extracts of *Cayratia trifolia* Leaves

Ni Putu Ermi Hikmawanti, Tuti Wiyati, M. Abdul Muis, Farah Aisyah Nurfaizah and Windy Septiani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012057

Chemical Component of Kencur (*Kaemferia galanga* L.) Ethanolic Extract Using Gas Chromatography-Mass Spectrometry

Ni Putu Ermi Hikmawanti, Supandi, Lusi Putri Dwita and Yeni

[+ Open abstract](#) [View article](#) [PDF](#)

-
- OPEN ACCESS** 012058
Effect of Glycerin as Plasticizer in Formulation of Grape Seed Oil (*Vitis vinifera* L.) Emulgel Peel-Off Mask
Fith Khaira Nursal, Nining and Aisyah Rahmani
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012059
The investigation of IL-1 β and oxytocin levels among teenager with primary dysmenorrhea
Mukhoirotin, Kurniawati and Diah Ayu Fatmawati
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012060
The Effects of Pineapple Extract Toothpaste (*Ananas comosus* L.Merr) on Saliva Flow Rate
Minarni, Susi and Murniwati
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012061
The use of coconut water (*cocos nucifera* L.) as alternative media to substitute Sabouraud Dextrose Agar (SDA) for the growth of *aspergillus flavus*
Widhorini, Asep Ginanjar Arip and Astrini Wulandari
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012062
Diversity of insect pollinator on farmland near to mount Ciremai National Park
Ai Nurlaila, Ika Karyaningsih, Nina Herlina, Iing Nasihin and Bambang Yudayana
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012063
Vegetation structure and species composition of habitat types *Goniothalamus macrophyllus* (Blume) Hook.f. and Thomson in Lowland Forest, Kuningan Regency, West Java
Ilham Adhya, Yayan Hendrayana, Toto Supartono, Agus Yadi Ismail and Nurdin
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012064
Activity of valerian catalase in Ultisol growing media by adding humic acid
Elly Proklamasiningsih and Pudji Widodo
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012065
Siam Madu citrus seeding in supporting the development of Sumatra citrus zone
Imelda S Marpaung, Perdinanta Sembiring, Moral A Girsang and Tommy Purba
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012066
A cross-sectional study of vitamin A, C and D and Iron daily intake among adolescents and its correlation with over nutrition status
M A M Putri, D Indarto and V Widyaningsih
[+ Open abstract](#) [View article](#) [PDF](#)

-
- OPEN ACCESS** 012067
Biochemical content of Robusta coffees under fully-wash, honey, and natural processing methods
Sri Wulandari, Makhmudun Ainuri and Anggoro Cahyo Sukartiko
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012068
Characterization of GABA (gamma-aminobutyric acid) levels some fermented food in Indonesia
Heny Herawati, Diana Nur Affah, Eni Kusumanigtyas, Sri Usmiati, Agus S. Soemantri, Miskiyah, Elmi Kamsiati and Muchamad Bachtiar
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012069
Differences in the effect of online nutrition education through lectures without and with online games on increasing knowledge of Nutrition, Iron, and vitamin C intake of young women
N S O Lorenza, E S Sulaeman and V Widyaningsih
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012070
Diversity and abundance of insect pollinator on *dimocarpus longan l.* in Sawitsari research station, Sleman, Yogyakarta
Ultha Rifqy Riswanta, Nico Chandra Aditya, Anas Sobri and Sukirno Sukirno
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012071
In silico development of new candidate of NADPH oxidase inhibitor for hypertension treatment
Agung Budi Laksono, Ratna Kusumawati, Yuliana Heri Suselo and Dono Indarto
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012072
Iron supplement for anemia developed from home industry waste of snake fruit Pondoh (*Snake fruit edulis Reinw.*)
K Natasia, D Indarto, B Wasita, D Melati and I K Ristanti
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012073
Study of proximate composition, antioxidant activity and sensory evaluation of cooked rice with addition of cherry (*Muntingia calabura*) leaf extract.
Yoyanda Bait, Djagal Wiseso Marseno, Umar Santoso and Yustinus Marsono
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012074
Study of rice seed certification at the Gorontalo Province seed certification supervision center
Merita Ayu Indrianti, Jefri Hala, Meity Melani Mokoginta, Mohamad Ervandi and Fahrullah
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012075
Variations in the incubation time of the *Staphylococcus aureus*, *Bacillus sp* and *Escherichia coli* cultures on the results of the gram stain visualization
Endah Prayekti and Thomas Sumarsono
[+ Open abstract](#) [View article](#) [PDF](#)

Food Technology

OPEN ACCESS

012076

[Innovation development information system for sales of traditional food processed product web based in the Cibinuang Village](#)

Tito Sugiharto, Mohammad Inwansyah, Sepphirotul Ajiziyah, Widi Heryanto and Syarif Hidayat

[+ Open abstract](#) [View article](#) [PDF](#)

Forest Science

OPEN ACCESS

012077

[Forest Land Management System and Effect on The Presence Of Birds at Nusa Laut Island](#)

M Tjoa and Fransina Latumahina

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012078

[Distribution and association of *Ficus* spp in the shrubs area of Gunung Ciremai National Park Indonesia](#)

Yayan Hendrayana, Toto Supartono, Ilham Adhya, Agus Yadi Ismail and Dede Kosasih

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012079

[Use of faecal pellet count method in estimating population density of mammals in Gunung Ciremai National Park](#)

Toto Supartono, Ilham Adhya, Yayan Hendrayana, Dede Kosasih and Bambang Yudayana

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012080

[The effort to cultivate natural dyes \(*Indigofera* Sp.\) in Timor Region, NTT](#)

Retno Agustarini, Yetti Heryati and Yelin Adalina

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012081

[The teak log volume estimation model for Sawn Timber: Case in Forest Management Unit \(FMU\) Bojonegoro – Perhutani – East Java - Indonesia](#)

L Abdulah, R Imanuddin and A P Utama

[+ Open abstract](#) [View article](#) [PDF](#)

Marine Science

OPEN ACCESS

012082

[Alternative income of Tomini Bay Coastal Communities \(case study in Bone Bolango District, Gorontalo Province, Indonesia\)](#)

Lis M Yapanto, Nuddin Harahab and Dahniar Th. Musa

[+ Open abstract](#) [View article](#) [PDF](#)

Oil Science

OPEN ACCESS

012083

[Effect of Heterogeneity of Reservoir Properties on Sandstone Formations in Oil Recovery](#)

Samsol, Sigit Rahmawan and Onnie Ridaliani

[+ Open abstract](#) [View article](#) [PDF](#)

Plant Science

OPEN ACCESS

012084

[Allicin Chemical Stability Test in the Phytosome of Garlic Extract \(*Allium sativum* L\)](#)

Rahmah Elfiyani, Anisa Amalia and Adesi Chenia

[+ Open abstract](#) [View article](#) [PDF](#)

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012085

[NANOEMULATION OF MIXED *Tephrosia vogelii* AND *Piper aduncum* AS AN ALTERNATIVE CONTROL OF CABBAGE PEST *Crociodolomia pavonana*](#)

Eka Candra Lina, Reflin, Lei Harismi Erlina and Duma Putri Tama

[+ Open abstract](#) [View article](#) [PDF](#)

Pollution

OPEN ACCESS

012086

[Effect of Personal Protective Equipment \(PPE\) on oxygen saturation and dehydration status in COVID-19 nurses in Gorontalo Province](#)

Yusrin Aswad and Suwarni Loleh

[+ Open abstract](#) [View article](#) [PDF](#)

Sustainable Development

OPEN ACCESS

012087

[Production Planning and Inventory Control of Atonic Fertilizer Products Using Static Lot Sizing Method](#)

Hendy Tannady, Joseph M J Renwarin, Andi Nurhikmah Daeng Cora and Edi Purwanto

[+ Open abstract](#) [View article](#) [PDF](#)

Waste Management System

OPEN ACCESS

012088

[Waste management model at Bugel Village – Kulonprogo District, Yogyakarta Special Province](#)

Darojad N. Agung Nugroho and Muhammad Dawam

[+ Open abstract](#) [View article](#) [PDF](#)

Water Science

OPEN ACCESS

012089

[Water availability model based on system dynamic: Sadar sub-watershed case study](#)

ET Asmorowati and D Sarasanty

[+ Open abstract](#) [View article](#) [PDF](#)

Weather and Climate Science

OPEN ACCESS

012090

[Spatial Analysis of Rainfall Return Period and Probable Maximum Precipitation over Central Java - Indonesia](#)

Andung Bayu Sekaranom, Muhammad Fianggoro and Rinut Manuhana Wicaksono

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To cite this article: Hurip Budi Riyanti and Y Yeni 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **819** 012054

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Determination of Level of Lead (Pb) and Cadmium (Cd) Migration on Bowl and Clear Plastic Cup Using Atomic Absorption Spectrophotometer

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Abstract. Food safety is a condition and efforts needed to prevent food from biological and chemical pollutants and other things that might irritate, harm, endanger human health. So the food is safe to consume. Besides, it should not against religion, faith, and culture. Chemical pollutants may come from migration of the food container or packaging, for example from a bowl or clear plastic cup. Migration happens as a result of the high temperature of food, duration of storage, and the production process. The higher the temperature the higher the possibility of migration. The existence of lead (Pb) and cadmium (Cd) in food may be because of environmental pollution, absorption of metal from equipment. Research has been conducted on the determination of the level of lead (Pb) and cadmium (Cd) from the migration of some bowls and plastic glasses that are available online by using spectrophotometer atomic absorption. The research is using acetic acid 4 % simulant. The sample is identified by using Near Infra-Red. The result of two kinds of plastic bowls and one kind of clear plastic cup are Polypropylene (PP). The sample is filled with acetic acid 4% simulant, stored in a dark place for twenty- four hours, then it is measured with Atomic Absorption Spectrophotometer (AAS). In all samples consist of two kinds of bowls and one clear plastic cup. The lead and cadmium are not detected with a limit of detection (LoD) Pb is 1.33 $\mu\text{g/ml}$ dan (LoD) Cd is 0.22 $\mu\text{g/ml}$, while the limit of quantitative (LoQ) Pb is 4.43 $\mu\text{g/ml}$ and (LoQ) Cd is 0.74 $\mu\text{g/ml}$. LoD dan LoQ for lead is too high because are using AAS Flame, while ideally using AAS Graphite Furnace.

1. Introduction

Currently, online trading is widely practiced, including bowls, plastic cups and is in great demand by the public because of its low prices and attractive shapes and colors. In the last two decades, plastics packaging has captured the global packaging market share, replacing cans and glass packaging. Some of the names of plastics commonly used are HDPE (High - Density Polyethylene), LDPE (Low - Density Polyethylene), PP (Polypropylene), PVC (Polyvinyl chloride), PS (Polystyrene), and PC (Polycarbonate). PE (Polyethylene) and PP have many similarities and are often referred to as polyolefins [1]. Food packaging is a material used to contain and/or wrap food, whether it is in direct contact with the food or not [2].

Lead (Pb) is widely used as packaging material, drains, household items, and decorations. In the form of lead oxide, it is used as a pigment/dye in the cosmetic and glaze industries as well as in the ceramic industry, some of which are used in household appliances [3]. Research on Pb, Cd, Hg, and Cu



content in *rejang* fish (*S. sihama*) was carried out by Nica Cahyani et al from August 2015 to January 2016, the results were very volatile. Most of the average heavy metal content of Pb, Hg, Cd, and Cu in each month has exceeded the threshold of the quality standard limit that has been set, but some are still below the quality standard threshold [4]. Meanwhile, the research results of Lian Dwi Fibrianti and R. Azizah showed that workers in the used battery home industry who had lead (Pb) levels in the blood $\geq 10 \mu\text{g} / \text{dL}$ had hypertension [5].

Suryo Irawan and Guntarti Supeni in 2013 researched on the levels of migrated metal in packs made of melamine, multilayer, and household appliances made of polymer with results that were still safe, which was below the threshold set by the POM [6].

BPOM head Regulation No. HK 03.1.23.07.11.6664 in 2011 determined that the total heavy metal content of lead (Pb), cadmium (Cd), chromium VI (Cr VI), and mercury (Hg) for all types of plastics is 1 ppm (parts per million). Under certain conditions, contact between plastic and food can cause migration (movement) of chemicals from the food container. Migration occurs due to the influence of the heat temperature of the food, storage time, and the processing process. The higher the temperature, the higher the possibility of migration [7]. According to Ir. Wawas Swathata frijiah from the Polymer Technology Center of the BPPT Ministry, in general plastics are safe as food packaging, as long as they are made according to applicable regulations. As food utensils, plastic made from virgin or not recycled plastic must be chosen. Also, it does not contain additives that exceed the specified threshold, has high chemical resistance, and is made with a good process [7].

Research conducted by Titin Agustina in 2014 shows that many foods are contaminated with heavy metals such as lead (Pb), mercury (Hg), Arsenic (As), and Cadmium (Cd) so that their safety is not guaranteed. The source of this contamination comes from environmental pollution such as motor vehicle fumes, the use of metals as a pest repellent (pesticides) [8].

Plastics consist of various polymers or monomers. Under certain conditions, contact between plastic and food can cause migration (transfer) of chemicals from the container to the food. Plastics are made by polymerization, namely arranging and forming a continuous plastic base material called monomers. Research conducted by [9] states that there is a migration of Cd and Pb metals from plastic containers to fresh, contacted milk. Cd metal migration that occurred ranged from 0.0000 - 0.0184 ppm for 4 hours of contact time and ranged between 0.0000 - 0.0480 ppm for 8 hours of contact time. Meanwhile, the Pb metal migration that occurred ranged from 0.0000 - 0.048 ppm for 4 hours of contact time and ranged from 0.0000 - 0.0677 ppm for 8 hours of contact time [9].

This study used samples of plastic bowls and clear plastic cus purchased online at low prices. The samples were identified to determine the type of plastic using the Near Infra-Red tool. To determine the levels of lead (Pb) and Cadmium (Cd) using a 4% acetic acid simulant which describes watery food such as soup, whether it is acidic or not [10]. Many people use plastic bowls for soup so that it is necessary to test the migration of Pb and Cd heavy metals from the bowl. Plastic cups are also often used for hot coffee or tea holders. Migration is the process of moving a substance from food packaging into food [2]. Food simulants are media used to imitate characteristics of certain food [2].

The results of this study can be used to determine the type of plastic from bowls and clear plastic cups and to determine whether or not lead (Pb) and cadmium (Cd) contamination comes from the migration of plastic bowls and clear plastic cups.

2. Method

The instrument and material: Atomic Absorption Spectrophotometer – AAS (Figure 1); Near Infra-Red– Phazir (Figure 2); Analytical balance. Standard of certified raw lead (Pb) and cadmium (Cd): 4% acetic acid solution, and aquademineral. The green plastic bowl; the white plastic bowl and the clear plastic cup (Figure 3).

A. IDENTIFICATION

Identification of the samples used by Near Infra-Red.

B. LEVELS OF GREEN AND WHITE PLASTIC BOWLS AND PLASTIC CUP

Preparation of sample:

The sample bowl was filled with acetic acid 4% to 0.6 cm below the top surface. Then the container is closed using a metal-free watch glass or aluminum foil and placed in a dark place at room temperature. Incubation was carried out at room temperature for 24 hours - Solution A. Figure 4[11]

Preparation of standard solution (S)

Standard solution of Pb and Cd each with a concentration of 1000 µg/ml

Preparation of Intermediate Standard Solution (IS)

Pipettes of 50.0 mL of main standard solution (S) of Pb and 5.0 mL of standard solution (S) of Cd are each put into a 100 mL volumetric flask, diluted with 4% acetic acid to the mark. Obtained a standard solution with a concentration of 500 µg / mL for the Pb standard and 50 µg / mL for the Cd standard.

Preparation of working standard (WS)

A serial standard solution is made with the concentration and dilution method as shown in the following table 1. (Solution B):

Table 1. Working standard

No.	Vol. from IS (ml)	The final vol. with 4%acetic acid (ml)	Concentration of Pb (µg/ml)	Concentration of Cd (µg/ml)
1	0	100.0	0	0
2	1.0	100.0	5	0.5
3	2.0	100.0	10	1.0
4	3.0	100.0	15	1.5
5	4.0	100.0	20	2.0
6	8.0	100.0	40	4.0

Preparation of Blank solution

Prepared in the same way as the sample-less test solution. - Solution C – Figure 5

Method of Determination

The absorption of solutions A, B, and C were measured using an atomic absorption spectrophotometer at the maximum wavelength of Pb λ : 283.3 nm and Cd λ: 228.8 nm .and the levels were calculated using the following formula:

$$\text{The levels of Pb or Cd (µg/mL)} = C_{sp} \times F$$

C_{sp} = concentration obtained from calculations using a calibration curve (µg/mL)

F = dilution (mL)



Figure 1. Atomic Absorption Spectrophotometer – AAS

Polychromix - Phazir - Handheld NIR System

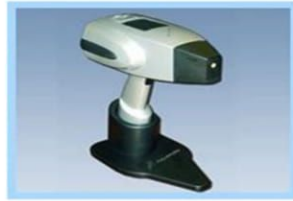


Figure 2. Near Infra-Red – Phazir



Figure 3. The samples are green bowl plastic; white bowl plastic and a clear plastic cup

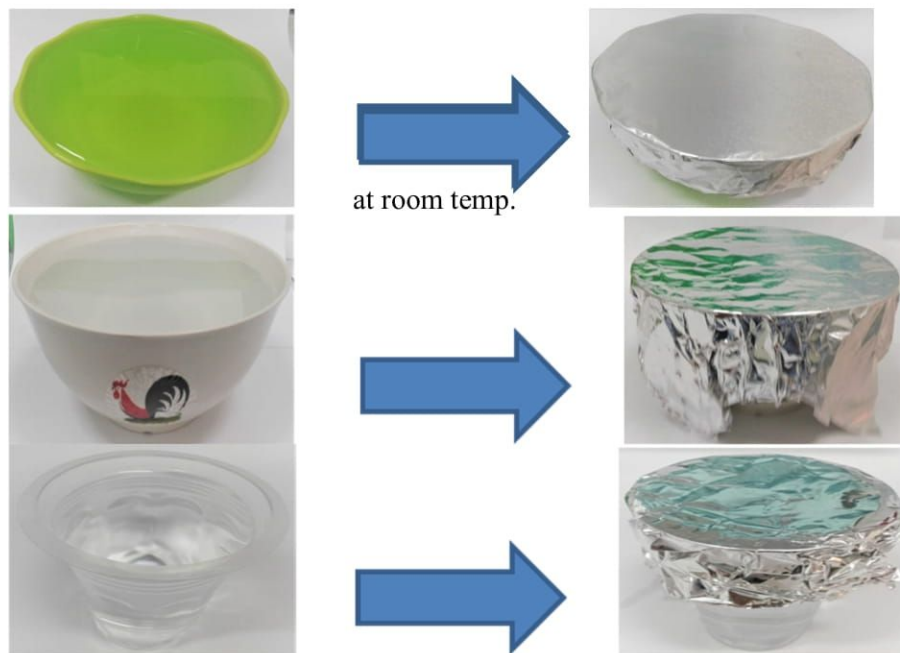


Figure 4. Preparation of samples



Figure 5. Preparation of blank







3. Results and Discussion

Identification: Method Near Infrared

RESULTS:

- a) The Green plastic bowl, polypropylene (PP) type
- b) The White plastic bowl, polypropylene (PP) type
- c) The Clear plastic cups, polypropylene (PP) type (Table 2)

Table 2. The Result of Identification

No.	No. of Sample	Figure	Plastic identification
1	1		 <p>Results : PP</p>
2	2		 <p>Result : PP</p>
3	3		 <p>Result : PP</p>

Determination Of Lead (Pb) And Cadmium (Cd)

a. Calibration Curve

1. Lead (Pb)

A = 0.0042092

B = 0.0061205

r = 0.9996

Y = 0.0061205 X + 0.0042092 (Figure 6)

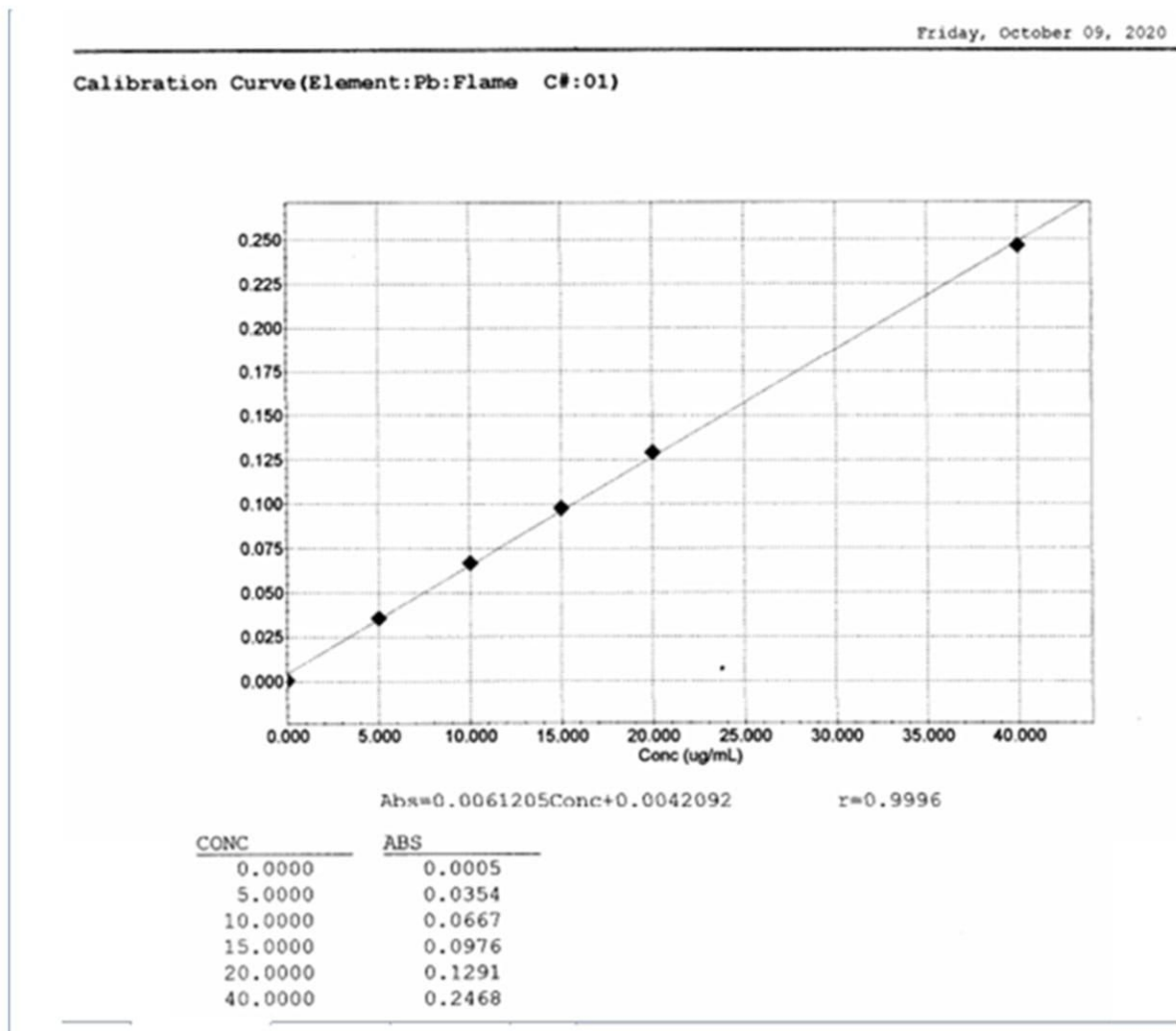


Figure 6. Calibration Curve of Pb

2. Cadmium (Cd)

A = 0.010597

B = 0.14548

r = 0.9989

Y = 0.14548 X + 0.010597 (Figure 7)

Friday, October 09, 2020

Calibration Curve(Element:Cd:Flame C#:01)

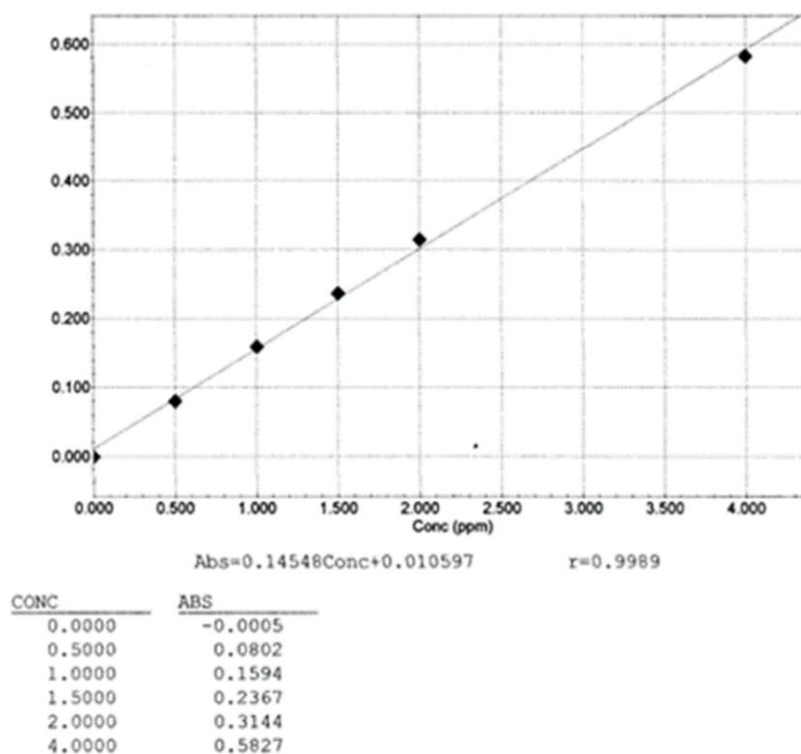


Figure 7. Calibration Curve of Cd

The level Pb and Cd of the green plastic bowl and white plastic bowl and a clear plastic cup

- The lead (Pb) : not detected with limit of detection (LoD) is 1.33 $\mu\text{g/ml}$ and limit of quantitation (LoQ) is 4.43 $\mu\text{g/ml}$
- The cadmium (Cd): not detection with limit of detection (LoD) is 0.22 $\mu\text{g/ml}$ and limit of quantitation LoQ) is 0.74 $\mu\text{g/ml}$.

Discussion:

The results are not detected possibly because:

- The type of plastic is polypropylene (PP), which is a type of plastic that is good for use as packaging
- Undetectable because the Pb LOQ is too high is 4.43 $\mu\text{g/ml}$, AAs - Graphite Furnace should be used

Suggestion:

- Need to do Pb testing using AAS - Graphite Furnace
- It is necessary to test Pb and Cd using hot water simulant.
- Limit of detection (LoD) Pb is 1.33 $\mu\text{g/ml}$ and (LoD) Cd is 0.22 $\mu\text{g/ml}$, while the limit of quantitative (LoQ) Pb is 4.43 $\mu\text{g/ml}$ and (LoQ) Cd =0.74 $\mu\text{g/ml}$. LoD and LoQ for Pb too high because of using AAS Flame, while ideally using AAS Graphite Furnace.

4. Conclusions

The type of sample consisted of green, white plastic bowls, and clear plastic cups namely polypropylene (PP). There was no migration of Pb and Cd metals from the three samples which were analyzed using AAS Flame with the LoD or Pb was 1.33 $\mu\text{g/ml}$ and LoQ was 4.43 $\mu\text{g/ml}$, while the LoD of Cd was 0.22 $\mu\text{g/ml}$ and LoQ is 0.74 $\mu\text{g/ml}$.

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