LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH*

Judul Jurnal Ilmiah (Artikel)	:	Photochemical Oxidation Process of Copper from Electroplating Wastewater: Process Performance and Kinetic Study		
Jumlah Penulis	:	4 orang		
Status Pengusul	:	**Penulis pertama**		
Identitas Jurnal Ilmiah	:	a. Nama Jurnal	:	Journal Processes
		b. Nomor ISSN	:	22279717 / Impact Factor: 2,973 (Q2)
		c. Volume, Nomor, Bulan, Tahun	:	8/issue 10/Oktober/2020
		d. Penerbit	:	MDPI AG, Switzerland
		e. DOI artikel (jika ada)	:	**https://doi.org/10.3390/pr8101276**
		f. Alamat web Jurnal	:	https://www.mdpi.com/2227-9717/8/10
		g. Terindeks di Scimagojr/SCIE-Science Citation Index Expanded (Clarivate Analytics, formerly Thomson Reuters), INSPEC (IET),Scopus (Elsevier)		

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- [ ] Jurnal Ilmiah Nasional Terakreditasi
- [ ] Jurnal Ilmiah Nasional terindeks di DOAJ, IPI, SINTA

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	Reviewer I	Reviewer II	
a. Kelengkapan unsur isi artikel (10%)	4,00	4,00	4,00
b. Ruang lingkup dan kedalaman pembahasan (30%)	11,00	11,00	11,00
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	11,00	11,50	11,25
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	11,00	11,00	11,00
Total = 100%	**37,00**	**37,50**	**37,25**
Nilai Pengusul (60% x nilai total)	**22,20**	**22,50**	**22,35**

Semarang, 2 Januari 2021

Reviewer 2

Prof. Dr. Ir. Budiyono, M.Si
NIP. 196602201991021001
Bidang Ilmu/Unit kerja : Teknik Kimia FT UNDIP

Reviewer 1

Prof. Ir. Didi Dwi Anggoro, M.Eng., P.hD
NIP. 196711141993031001
Bidang Ilmu/Unit kerja : Teknik Kimia FT UNDIP

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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH*

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Jumlah Penulis	:	4 orang
Status Pengusul	:	**Penulis pertama**
Identitas Jurnal Ilmiah	:	a. Nama Jurnal : Journal Processes b. Nomor ISSN : 22279717 / Impact Factor: 2,973 (Q2) c. Volume, Nomor, Bulan, Tahun : 8/issue 10/Oktober/2020 d. Penerbit : MDPI AG, Switzerland e. DOI artikel (jika ada) : **https://doi.org/10.3390/pr8101276** f. Alamat web Jurnal : https://www.mdpi.com/2227-9717/8/10 g. Terindeks di Scimagojr/SCIE-Science Citation Index Expanded (Clarivate Analytics, formerly Thomson Reuters), INSPEC (IET),Scopus (Elsevier)
Kategori Publikasi Jurnal Ilmiah (beri ✓pada kategori yang tepat)	:	☑ Jurnal Ilmiah Internasional / Internasional bereputasi ☐ Jurnal Ilmiah Nasional Terakreditasi ☐ Jurnal Ilmiah Nasional terindeks di DOAJ, IPI, SINTA

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir Yang Diperoleh
	Internasional/ Internasional bereputasi** ☑	Nasional Terakreditasi ☐	Nasional*** ☐	
a. Kelengkapan unsur isi artikel (10%)	4,00			4,00
b. Ruang lingkup dan kedalaman pembahasan (30%)	12,00			11,00
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	12,00			11,00
d. Kelengkapan unsur dan terbitan/jurnal (30%)	12,00			11,00
Total = (100%)	40,00			37,00
Nilai Pengusul=	**(0,6x37,00)=22.20**			

Catatan Penilaian Artikel oleh Reviewer:

a. **Kesesuaian dan kelengkapan unsur isi jurnal:**
Artikel yang dipublikasi terdiri dari abstract, introduction, material and method, results and discussions, conclusions, acknowledgments serta references. Artikel ditulis sesuai dengan petunjuk penulisan Jurnal.

b. **Ruang lingkup dan kedalaman pembahasan:**
Substansi artikel sesuai dengan bidang ilmu pengusul, yaitu Teknik Kimia. Kebaruan artikel ini membahas tentang tinjauan model kinetika dan performansi proses oksidasi logam Cu pada pengolahan limbah elektroplating. Pembahasan cukup baik yaitu dengan menjelaskan *reasoning* atau *scientific background* nya, namun analisis secara tekno-ekonomis belum dipertimbangkan. Pembahasan dilengkapi dengan sitasi sebanyak 68% dari jumlah total artikel yang disitasi. Data dilengkapi dengan 11 figure sehingga mempermudah dalam memahami pembahasan.

c. **Kecukupan dan kemutakhiran data/informasi dan metodologi:**
Kemutakhiran data/informasi artikel baik, dengan jumlah pustaka yang digunakan sebanyak 31 pustaka atau 60 persen merupakan pustaka 10 tahun terakhir. Penyajian data cukup lengkap didukung oleh uji karakteristik yang memadai.

d. **Kelengkapan unsur dan kualitas terbitan**
Jurnal digolongkan jurnal internasional bereputasi dengan nilai Impact Factor (IF) tinggi, untuk tahun (2019)= 2,973. Jurnal Processes memiliki kategori Quartile 2 dan nilai SJR = 0,4 (2019); H index = 20; Publisher adalah Multidisciplinary Digital Publishing Institute (MDPI). Jumlah anggota Editorial board (2020) adalah 281 dan dari berbagai Negara, diantaranya USA, Spanyol, Italia, Jerman, Polandia, Portugal, Thailand, China, dan Australia. Nilai similaritas artikel adalah 13%.

Semarang,
Reviewer 1

Prof. Ir. Didi Dwi anggoro, M. Eng., PhD
NIP. 196711141993031001
Unit kerja : Teknik Kimia FT UNDIP

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH*

Judul Jurnal Ilmiah (Artikel)	:	Photochemical Oxidation Process of Copper from Electroplating Wastewater: Process Performance and Kinetic Study		
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		d. Penerbit	:	MDPI AG, Switzerland
		e. DOI artikel (jika ada)	:	**https://doi.org/10.3390/pr8101276**
		f. Alamat web Jurnal	:	https://www.mdpi.com/2227-9717/8/10
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- [ ] Jurnal Ilmiah Nasional terindeks di DOAJ, IPI, SINTA

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir Yang Diperoleh
	Internasional/ Internasional bereputasi** [√]	Nasional Terakreditasi [ ]	Nasional*** [ ]	
a. Kelengkapan unsur isi artikel (10%)	4,00			4,00
b. Ruang lingkup dan kedalaman pembahasan (30%)	12,00			11,00
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	12,00			11,50
d. Kelengkapan unsur dan terbitan/jurnal (30%)	12,00			11,00
Total = (100%)	40,00			37,50
Nilai Pengusul=	**(0,6x37,50)=22.5**			

Catatan Penilaian Artikel oleh Reviewer:

a. **Kesesuaian dan kelengkapan unsur isi jurnal:**
Kesesuaian dan unsur isi jurnal lengkap dan tersaji dengan baik, terdiri dari abstrak, pendahuluan, bahan dan metode, hasil dan pembahasan, kesimpulan, ucapan terima kasih serta daftar pustaka.

b. **Ruang lingkup dan kedalaman pembahasan:**
Ruang lingkup artikel mengkaji kinetika reaksi dan kinerja proses degradasi logam Cu pada industri elektroplating dengan oksidasi fotokimia. Pembahasan cukup komprehensif dengan merujuk peneliti sebelumnya, didukung sitasi dalam pembahasan sebanyak 35 artikel dari 51 buah (68,7%). Penyajian data cukup baik dilengkapi dengan 2 tabel dan 11 gambar.

c. **Kecukupan dan kemutakhiran data/informasi dan metodologi:**
Kemutakhiran data didukung referensi yaitu 10 tahun terakhir sebanyak 31 artikel dari 51 artikel yang disitasi, atau 60,8 %. Penyajian data cukup lengkap didukung oleh uji karakteristik limbah (AAS, SEM, XRD) serta *scientific background* yang baik. Namun analisis secara tekno-ekonomis belum dipertimbangkan.

d. **Kelengkapan unsur dan kualitas terbitan**
Jurnal Processes diterbitkan oleh MDPI AG Switzerland. Termasuk kategori Jurnal Q2 (2019), dengan nilai SJR:0,4 (2019) dan Impact Factor 2,973 (2019). H index = 20; ISSN: 22279717. Jurnal terindeks di Scopus (Elsevier), Scimagojr/SCIE-Science Citation Index Expanded (Clarivate Analytics, formerly Thomson Reuters). Artikel memiliki nilai similaritas berdasarkan turnitin adalah 13%.

Semarang,
Reviewer 2

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Department of Chemical Engineering, University of Almería, 04120 Almería, Spain

Interests: biomass conversion; biofuel production; phytoplankton ecology; algae culture; transesterification; microalgal biotechnology; photobioreactors

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Prof. Dr. Yongtae Ahn

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Department of Energy Engineering, Gyeongnam National University of Science and Technology, Dongjin-ro 33, Jinju, Gyeongnam 52725, Korea

Interests: Bioelectrochemical anaerobic digestion; membrane filtration; energy/resources recovery from organic wastes

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Prof. Dr. Donatella Aiello

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Department of Chimica e Tecnologie chimiche, University of Calabria, I-87030 Arcavacata di Rende (CS), Italy

Interests: mass spectrometry application in analytical chemistry; characterization of analytes in biological systems, use of laser desorption ionization methods to study biological samples, molecular clusters and metal cation complexes; application of ’omics technologies for metabolites detection in natural matrices; Development of MS based strategies for quantitative assay in complex samples

Dr. Muthanna H. Al-Dahhan

Website (http://chemeng.mst.edu/facultystaffandfacilities/aldahhan/)

Department of Chemical and Biochemical Engineering, Missouri University of Science and Technology, 1101 North State Street, 110 Bertelsmeyer Hall, Rolla, MO 65409-1230, USA

Interests: multiphase reaction engineering; advanced measurement techniques; clean and alternative energy and environment

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Institute for Research on Combustion (IRC)-CNR, P.le V. Tecchio, 80-80125 Napoli, Italy
Interests: fluidization; energy; fine cohesive powders; biomass; heterogeneous catalysis; CO_2 capture; thermochemical energy storage; concentrated; solar power; hydrogen
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Website (https://www.concordia.ca/faculty/chunjiang-an.html)
Department of Building, Civil and Environmental Engineering, Concordia University, Montreal H3G 1M8, QC, Canada
Interests: solid waste composting and digestion; waste utilization and resource recovery; advanced physiochemical and biological treatment; contaminant transport in multiphase; environmental risk assessment and management; synchrotron-assisted environmental process analysis; surface water and groundwater quality; environmental sustainability
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Prof. Dr. Ofelia Anjos
Website (https://orcid.org/0000-0003-0267-3252) SciProfiles (https://sciprofiles.com/profile/119092)
1. Instituto Politécnico de Castelo Branco, 6001-909 Castelo Branco, Portugal
2. CEF – Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, 1349-017 Lisboa, Portugal
Interests: alcoholic beverages; spectroscopic techniques; FTIR; NIR; Raman; chromatographic techniques; bee products
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Prof. Dr. Gurutze Arzamendi

Chemical Engineering, Public University of Navarre, Spain
Interests: kinetics; biodiesel; microreactors; mathematical modeling and computer simulation; computational fluid dynamics (CFD)

Prof. Dr. Suttichai Assabumrungrat
Website (http://chem.eng.chula.ac.th/faculty-member/suttichai-assabumrungrat)
Center of Excellence on Catalysis and Catalytic Reaction Engineering, Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330, Thailand
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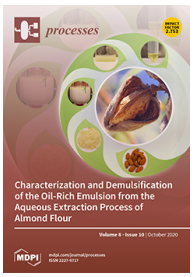
Processes, Volume 8, Issue 10 (October 2020) – 128 articles



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by **Merlin Raud (https://sciprofiles.com/profile/470119)**, **Kaja Orupõld (https://sciprofiles.com/profile/956482)**, **Lisandra Rocha-Meneses (https://sciprofiles.com/profile/497930)**, **Vahur Rooni (https://sciprofiles.com/profile/author/TFdKWU1PblBYditDWXVhcjhSWTI5L243TUNVSGRNM3pJNVpkdFJPdWRVbz0=)**, **Olev Träss (https://sciprofiles.com/profile/author/eWFza3F3VisvcGxud2RVWE8vZmpLSnh2K2NQUGpGOFc4VDJjb3VqTHFqND0=)** and **Timo Kikas (https://sciprofiles.com/profile/434647)**

Processes **2020**, *8*(10), 1327; **https://doi.org/10.3390/pr8101327 (https://doi.org/10.3390/pr8101327)** - 21 Oct 2020

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Abstract Results from an investigation of the mechanical size reduction with the Szego Mill™ as a pretreatment method for lignocellulosic biomass are presented. Pretreatment is a highly expensive and energy-consuming step in lignocellulosic biomass processing. Therefore, it is vital to study and optimize different **[...] Read more.**

(This article belongs to the Special Issue **Sustainable Development of Waste towards Green Growth (/journal/processes/special_issues/waste_green_growth)**)

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by Khaled Mohamed Nabil I. Elsayed (https://sciprofiles.com/profile/1068028), Rabee Rustum (https://sciprofiles.com/profile/362695) and Adebayo J. Adeloye (https://sciprofiles.com/profile/531300)

Processes **2020**, *8*(10), 1280; https://doi.org/10.3390/pr8101280 (https://doi.org/10.3390/pr8101280) - 13 Oct 2020

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Abstract Estimating groundwater recharge using mathematical models such as water budget or soil water balance method has been proved to be very difficult due to the complex, uncertain multidimensional nature of the process, despite the simplicity of the concept. Artificial Intelligence (AI) techniques have **[...] Read more.**

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(/2227-9717/8/10/1279/pdf)

Numerical Investigation on the Transient Flow of a Boiler Circulating Pump Based on the Shear Stress Transport Turbulence Model (/2227-9717/8/10/1279)

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Processes **2020**, *8*(10), 1279; https://doi.org/10.3390/pr8101279 (https://doi.org/10.3390/pr8101279) - 13 Oct 2020

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Abstract Based on the shear stress transport (SST) turbulence model, the influence of different outlet pipe angles on the head and efficiency of a boiler circulating pump was analyzed. When the outlet pipe angle changed from 115° to 130°, the head and efficiency of **[...] Read more.**

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The Impacts of Tracking System Inaccuracy on CPV Module Power (/2227-9717/8/10/1278)

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Processes **2020**, *8*(10), 1278; https://doi.org/10.3390/pr8101278 (https://doi.org/10.3390/pr8101278) - 12 Oct 2020

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Abstract The accuracy and reliability of solar tracking greatly impacts the performance of concentrator photovoltaic modules (CPV). Thus, it is of utmost significance to know how deviations in tracking influence CPV module power. In this work, the positioning characteristics of CPV modules compared to [...] **Read more.**

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Abstract Due to the harmful effects and depletion of non-renewable energy resources, the major concerns are focused on using renewable energy resources. Among them, the geothermal energy has a high potential in volcano regions such as the Middle East. The optimization of an organic **[...] Read more.**

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Abstract An investigation of the process of ozone combined with ultraviolet radiation has been carried out in order to establish the kinetics for photochemical oxidation of copper (Cu) from electroplating wastewater. The effects of operating parameters, including initial Cu concentration, ozone dosage, UV irradiation **[...] Read more.**

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Abstract Paddy fields emit considerable amounts of methane (CH_4), which is a potent greenhouse gas (GHG) and, thereby, causes significant environmental impacts, even as they generate wealth and jobs directly in the agricultural sector, and indirectly in the food-processing sector. Application of **[...] Read more.**

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by Daryl Rafael Osuna-Laveaga (https://sciprofiles.com/profile/author/TVRKV04xMHdrQTc2R1h0NVk4aThqY2FtR0Y2SUl6dEUxdUFRdkM4eWdlRT0=), Octavio García-Depraect (https://sciprofiles.com/profile/1284468), Ramiro Vallejo-Rodríguez (https://sciprofiles.com/profile/140007), Alberto López-López (https://sciprofiles.com/profile/author/QlFlWDE5WjZXZUl1NGhrTXlYaFRicDNwMjdaV2pwQmdQc3JJaUZtZ2FlVT0=) and Elizabeth León-Becerril (https://sciprofiles.com/profile/381744)

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Abstract The combined effects of three key ozonation process parameters on the integrated ozonation-enzymatic hydrolysis pretreatment of sugarcane bagasse (SCB) were investigated, with emphasis on the relationship between sugar release and ozone consumption. A lab-scale fixed bed reactor was employed for ozonation at varying **[...] Read more.**

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Phosphorus-Doped Carbon Supported Vanadium Phosphate Oxides for Catalytic Oxidation of 5-Hydroxymethylfurfural to 2,5-Diformylfuran (/2227-9717/8/10/1273)

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Abstract 2,5-diformylfuran (DFF) is an important downstream product obtained by selective oxidation of the biomass-based platform compound 5-hydroxymethylfurfural (HMF). In this study, a phosphorus-doped carbon (P-C) supported vanadium phosphate oxide (VPO) catalyst was successfully prepared and showed remarkably high catalytic activity in the selective **[...] Read more.**

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Abstract Active seismic faults in the Pacific Northwest area have encouraged electric utilities in the region to deeply contemplate and proactively intervene to support grid resilience. To further this effort this research introduces Monte Carlo (MC)-based power system modeling as a means to inform **[...] Read more.**
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Photochemical Oxidation Process of Copper from Electroplating Wastewater: Process Performance and Kinetic Study

Aji Prasetyaningrum *, Teguh Riyanto, Mohamad Djaeni and Widayat Widayat

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Abstract: An investigation of the process of ozone combined with ultraviolet radiation has been carried out in order to establish the kinetics for photochemical oxidation of copper (Cu) from electroplating wastewater. The effects of operating parameters, including initial Cu concentration, ozone dosage, UV irradiation intensity, and pH value on the photochemical oxidation of Cu have been studied comprehensively. The Cu concentration during the reaction was identified using atomic absorption spectroscopy (AAS) method. The solid product was analyzed using X-ray diffraction (XRD) and scanning electron microscope–energy-dispersive X-ray (SEM–EDX) methods. It was found that the UV-Ozone process has high performance on Cu removal compared to UV and Ozone processes due to the high production rate of HO• radicals. It was also found that the solid product from the UV-Ozone process was CuO monoclinic crystal phase. The initial Cu concentration, ozone dosage, and pH value were significantly affected the Cu removal efficiency. On the other hand, the UV irradiation intensity was not significant; however, it has responsibility in promoting the ozone photolysis. The kinetics model for the photochemical oxidation of Cu was established following the first-order kinetic model. Furthermore, the reaction mechanism was also developed.

Keywords: photochemical oxidation; Cu; kinetics; ozone; ultraviolet irradiation; advanced oxidation process

1. Introduction

Heavy metals have become a global issue of environmental and public health concern because of their toxicity and bioaccumulation in the human body and food chain [1]. The effects of urbanization and industrialization cause an increase in heavy metal pollution to the environment [2]. High toxicity and nonbiodegradability of heavy metals caused a number of environmental problems [3]. The accumulation of heavy metals in the atmosphere is responsible for both natural and anthropogenic activities [4]. Copper (Cu), as an essential trace element, is required by biological systems for the activation of some enzymes during photosynthesis. However, at higher concentrations, it shows harmful effects on the human body. Continuous exposure may lead to kidney damage and even death. Cu is also toxic to a variety of aquatic organisms even at very low concentrations. Mining, metallurgy, and industrial applications are the major sources of Cu exposure in the environment [5].

There were several techniques for the treatment of industrial wastewater containing heavy metals, including chemical precipitation, ion exchange, coagulation–flocculation, flotation, membrane filtration, electrochemical treatment, magnetic separation and purification, biosorption, and nanotechnology [6]. Advanced oxidation processes (AOPs) are promising, efficient, and environmentally friendly methods

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Review

A Critical Review on Advancement and Challenges of Biochar Application in Paddy Fields: Environmental and Life Cycle Cost Analysis

Ali Mohammadi [1,*], Benyamin Khoshnevisan [2], G. Venkatesh [1] and Samieh Eskandari [1]

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Abstract: Paddy fields emit considerable amounts of methane (CH_4), which is a potent greenhouse gas (GHG) and, thereby, causes significant environmental impacts, even as they generate wealth and jobs directly in the agricultural sector, and indirectly in the food-processing sector. Application of biochar in rice production systems will not just help to truncate their carbon footprints, but also add to the bottom-line. In this work, the authors have reviewed the literature on climate change, human health, and economic impacts of using organic residues to make biochar for the addition to croplands especially to rice paddy fields. Biochar-bioenergy systems range in scale from small household cook-stoves to large industrial pyrolysis plants. Biochar can be purveyed in different forms—raw, mineral-enriched, or blended with compost. The review of published environmental life cycle assessment (E-LCA) studies showed biochar has the potential to mitigate the carbon footprint of farming systems through a range of mechanisms. The most important factors are the stabilization of the carbon in the biochar and the generation of recoverable energy from pyrolysis gases produced as co-products with biochar as well as decreased fertiliser requirement and enhanced crop productivity. The quantitative review of E-LCA studies concluded that the carbon footprint of rice produced in biochar-treated soil was estimated to range from −1.43 to 2.79 kg CO_2-eq per kg rice grain, implying a significant reduction relative to rice produced without a biochar soil amendment. The suppression of soil-methane emission due to the biochar addition is the dominant process with a negative contribution of 40–70% in the climate change mitigation of rice production. The review of the life cycle cost studies on biochar use as an additive in farmlands demonstrated that biochar application can be an economically-feasible approach in some conditions. Strategies like the subsidization of the initial biochar capital cost and assignment of a non-trivial price for carbon abatement in future pricing mechanisms will enhance the economic benefits for the rice farmers.

Keywords: rice cropping systems; biochar; pyrolysis gas; E-LCA; carbon abatement; human health; economic analysis

1. Introduction

Recent studies have provided important information on climate change mitigation. The current greenhouse gas (GHG) emissions trend suggests that the average global temperature will rise by over 4 °C by 2100 [1,2]. Since global warming may adversely affect biodiversity, ecosystems, and human survival [3], many scientists have shown a renewed interest in new approaches to geo-engineering and reforestation through which excess carbon dioxide (CO_2) from the atmosphere

processes

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Article

The Impacts of Tracking System Inaccuracy on CPV Module Power

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Abstract: The accuracy and reliability of solar tracking greatly impacts the performance of concentrator photovoltaic modules (CPV). Thus, it is of utmost significance to know how deviations in tracking influence CPV module power. In this work, the positioning characteristics of CPV modules compared to the focus points were investigated. The performance of CPV modules mounted on a dual-axis tracking system was analysed as a function of their orientation and inclination. The actual experiment was carried out with CPV cells of 3 mm in diameter. By using a dual tracking system under real weather conditions, the module's position was gradually modified until the inclination differed by 5° relative to the optimal position of the focus point of the CPV module. The difference in inclination was established by the perfect perpendicularity to the Sun's rays. The results obtained specifically for CPV technology help determine the level of accuracy that solar tracking photovoltaic systems are required to have to keep the loss in power yield under a certain level. Moreover, this power yield loss also demonstrated that the performance insensitivity thresholds of the CPV modules did not depend on the directions of the alterations in azimuthal alignment. The novelty of the research lies in the fact that earlier, no information had been found regarding the tracking insensitivity point in CPV technologies. A further analysis was carried out to compare the yield of CPV to other, conventional photovoltaic technologies under real Central European climate conditions. It was shown that CPV needs a sun tracking accuracy of at least 0.5° in order to surpass the yield of other PV technologies. Besides providing an insight into the tracking error values of solar tracking sensors, it is believed that the results might facilitate the planning of solar tracking sensor investments as well as the economic calculations related to 3 mm cell diameter CPV system investments.

Keywords: solar energy; concentrator photovoltaic module; sun-tracking; sun-tracking sensor; azimuth angle; tilt angle

1. Introduction

1.1. Photovoltaic Technologies and Their Markets

In the global challenge of securing energy for the world's growing needs in a way that is sustainable, sufficiently diverse, and conducive to the worldwide efforts to reduce CO_2 emissions, renewable sources of energy have a key role to play [1]. One of the available solutions, generating energy by utilizing the energy of the Sun, satisfies all the above criteria, being both sustainable and environmentally friendly