Value of Biorefinery Research Mapping: A Scientometric Overview

Andre Septianto
Chemical Engineering Department
Universitas Nahdlatul Ulama Sidoarjo
Sidoarjo 61218, Indonesia
andreseptianto@unusida.ac.id

Elsa Rosyidah
Environmental Engineering Department
Universitas Nahdlatul Ulama Sidoarjo
Sidoarjo 61218, Indonesia
elsarosyidah@unusida.ac.id

Agung Purnomo
Entrepreneurship Department
BINUS Business School Undergraduate Program
Bina Nusantara University
Jakarta 11480, Indonesia
agung.purnomo@binus.ac.id

Abstract

This research purpose was to present a thorough knowledge map of the intellectual structure based on the dataset collected from the Scopus database. A scientometric approach was employed by analyzing 3,675 scientific articles published between 2002 and 2020, using the VOSViewer application, and analyzing the search results function on Scopus. The study discusses an overview and the prominence of articles, authors, organization, country, publication sources, collaborative researcher, and research themes. There were three category maps of collaborative researchers. Based on the identification of a collection of knowledge generated from seventeen-year publications, this research proposes a grouping of biorefinery research themes: Hydrolysis, Chemistry, Fermentation, Biomass as HCFB themes.

Keywords
Biorefinery, Intellectual Structure, Research mapping, Renewable energy, Scientometric.

1. Introduction

Living thing products or services are being consumed more globally as a result of rapid population growth and industrialization. A huge number of resources, raw materials, and processing steps are required to manufacture basic chemicals and intermediates for a wide range of products. Furthermore, our planet faces other issues, including the exhaustion of fossil-based raw materials, price volatility in biofuels, pollution, and rising greenhouse gas (GHG) emissions (Balla et al., 2021). The world's present dependence on fossil fuels as the primary source of energy is unsustainable. Biofuels made from renewable have been intensively studied as a potential source of energy. In terms of land utilization, it is vital that these fuels would not compete with agricultural production (Byrne et al., 2021). Alternatives aviation fuels are viewed as a viable short-term solution for reducing carbon emissions in our aircraft (Prussi, Weindorf, Buffi, Sánchez López, & Scarlat, 2021). Global energy usage increased twice as fast in 2018 as it did in 2010 (Roles, Yarnold, Hussey, & Hankamer, 2021). Over than 80% of our present energy production is derived from fossil fuels. Concerns about the effects of non resources on global warming, people's health, and ecology have spurred academics to look for renewable sources to meet our expanding energy need (Chen, Wang, Zhang, & Feng, 2021).

The notion of biorefinery arose in the context of population expansion, growing human energy and resource consumption, and diminished effectiveness of the planet as a result of different anthropogenic disruptions (Zhang & Thomsen, 2021). Biorefinery, an alternative technique to traditional oil refineries, aims to utilize renewable

lignocellulosic biomass to produce fuels, chemicals and bio-based materials (Chu et al., 2021). Growing chemical and energy demands have prompted a move toward the study of alternate materials (Dai, Huang, Jiang, Zhou, & Xu, 2021). Meeting the growing need for energy inside a renewables, low-carbon, and economically viable way is a huge worldwide challenge. The transport industry is one of the largest energy users on the planet (Kumar, Long, Arora, & Singh, 2021). Effective and resilient biorefineries can become increasingly important in the production of rising petrochemical products and molecules in the near future (Sillero et al., 2021). As transportation fuels, biofuels have numerous environmental and practical advantages. They are among the best non - renewable energy alternatives, thanks to their ability to produce negative carbon dioxide emissions, which is crucial for achieving global clean-energy goals (Zaky, 2021).

Current feedstock methods, which mostly rely on the utilization of conventional food-based or lignocellulosic biomass, have severely hindered the commercialisation of biofuels, which are potential viable and sustainable alternatives for fossil-based fuels (Figueroa-Torres, Pittman, & Theodoropoulos, 2021). Through thermo - chemical processes such as rapid pyrolysis, tree biomass has been regarded a promising raw source for biofuel generation (Lan et al., 2021). Bioethanol is a regenerative substance that can immediately replace its fossil equivalent, despite the fact that it is difficult to produce from residual biomass (Bertacchi, Ruusunen, Sorsa, Sirviö, & Branduardi, 2021). Hybrid bio-thermochemical techniques have the ability to provide more raw material versatility for bioenergy and bioproduct manufacturing (Pacheco et al., 2021). Aquatic biomass is a suitable source for the construction of third-generation biorefineries since it is continuous, sustainable, and abundant (del Río, Gullón, Pérez-Pérez, Romaní, & Garrote, 2021). Biorefineries and bio-based enterprises must become more resources efficient and effective of waste and by-product handling as part of the transition to a cyclical and bio-based economic. If employed in a sustainable method that also has a minimal environmental impact and also preserves or restores energy, nutrients, or other pretty useful elements, organic by-products and wastes flows can be a major source of value (Hagman & Feiz, 2021). The transformation of catalyst biomass into valuable chemicals has gotten a lot of interest because of the economically and environmentally implications. Compound, a flexible biorefinery substrate molecule utilized as a substrate for the synthesis of fuels and chemicals, is of specific interest. (Liu, Meng, Li, & Yang, 2021). Bioeconomics can help convert the current economic model into one that has fewer adverse environmental and health consequences from production cost (Barrio, Francisco, Leoncini, Wietschel, & Thorenz, 2021).

Research related to the Biorefinery in engineering and Energy has been carried out and developed at the international level over the last few years. However, previous studies on the topic of the Biorefinery were typically restricted to a single nation in particular (Hennequin, Polizzi, Fennell, & Hallett, 2021) and one field (Corderi et al., 2021). There hasn't been much reported on the Biorefinery, despite providing a large image map visualized on a global scale year after year using data from many published studies. There has been no publication that directly discusses the strong positive relationship between scholars and scholarly studies' influence.

One of the methods used to view research, in general, is the bibliometric method. Bibliometrics is a method for measuring and analyzing scientific references with a combination of mathematical and statistical methods. Bibliometrics is a statistical technique for analyzing bibliometric publication data such as peer-reviewed journal articles, reports, reviews, books, periodicals, conference proceedings, and related publications. Bibliometric methods have been widely used to present the relationship between the quantitative methods and the research domain (IGI Global, 2021). This study proposes research questions, what is the mapping and trend of Biorefinery research using visual bibliometric analysis? From a bibliometric review, this study aims to visually study mapping and research trends in the field of the Biorefinery on an international scale.

This scientific article is organized into several sections. The first part of the introduction discusses the background, questions, and objectives of the study. The second part of the method describes the scientific approach used in the research. The third section results and discussion explains the research findings and the fourth section summarizes the essence of the research. Finally, followed by acknowledgments, and references.

2. Research Methods

This study has used bibliometric analysis in a comprehensive literature database. This survey has identified relevant keywords related to a Biorefinery study to search for and identify related articles in the global Scopus database. Researchers have used the Scopus database as the main source of information because it is considered a reliable source of scientific publications by academics.

This research has used the keyword "Biorefinery" in the title, abstract, and author keywords to get the necessary data from the Scopus database. Data mining is limited to annual data to obtain fully published data for twelve months each

year. Data mining uses the following search query option (TITLE-ABS-KEY ("biorefiner*") AND (LIMIT-TO (SUBJAREA , "CENG")) AND (LIMIT-TO (SRCTYPE , "j")) AND (EXCLUDE (PUBYEAR , 2022) OR EXCLUDE (PUBYEAR , 2021)) 2003-2020) as of November 2021. In this step, we have found 3.675 publications over the last 17 years from 2002 to 2020. In the study At this point, the Scopus result metadata has been extracted in the CSV dataset format (Septianto & Purnomo, 2021).

The Scopus website provides an analyze search results function that displays bibliometric information from selected publications. We have used this service to analyze and visualize the publication productivity of researchers, institutions, and countries. Besides, this feature is to measure the number of annual publications and publication citations, as well as the proportion of subject areas and source documents (Purnomo, Agustina, Septianto, Liahmad, & Prasetyo, 2020),(Purnomo, Firdaus, Sutiksno, Latukismo, & Rachmahani, 2020).

In the next stage, the researcher analyzed the collected documents using the VOSviewer ver. 1.6.16 for co-occurrence and co-authorship analysis. This study has applied co-authorship analysis with the author's analysis unit and the full computation systematic technique using VOSViewer to obtain a research network of international collaborative researchers. This study performs an in-depth co-occurrence analysis with keyword relationship analysis as well as a fully systematic computation technique using VOSViewer to generate a network of keyword maps for research themes (Ranjbar-Sahraei & Negenborn, 2017; van Eck & Waltman, 2010). Simple statistics and tables have been calculated and tabulated using Microsoft Excel. Then, the research results were synthesized and triangulated.

3. Result

This section describes the growing results of data based on the most common organizational affiliation, nations, individual studies, the largest frequency of subject areas, yearly source documents, annual documents and cited papers, publication of the map, and networks of authorship in the field of the Biorefinery.

3.1 Most Frequent Country Affiliation of Biorefinery

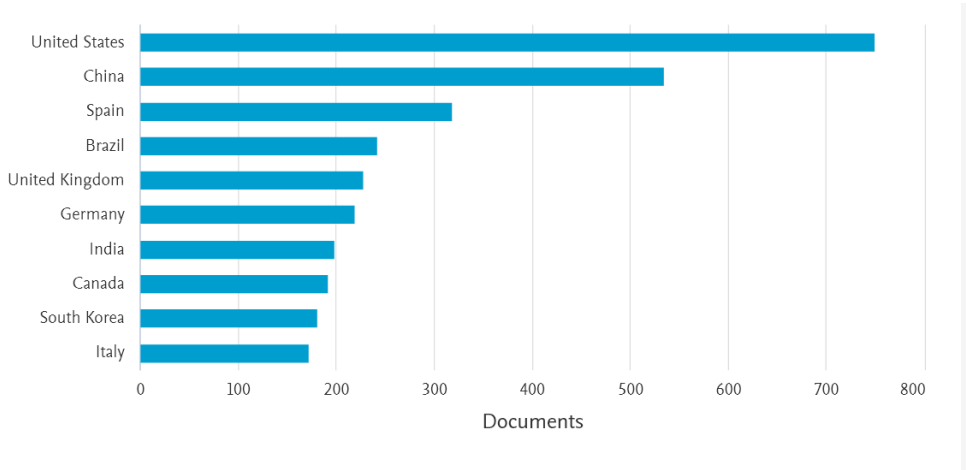

Figure 1. Country Number of Biorefinery Per Year

There 3.675 countries were identified to have researched Biorefinery. United States was the leading research nation in Biorefinery publications (n = 749) and China was next (n= 534). Spain (n = 318), Brazil (n = 241), United Kingdom (n = 227), Germany (n = 218), India (n = 197), Canada (n = 191), Sourh Korea (n = 180), and Italy (n = 171).

The US Department of Energy defines a biorefinery as an overall concept of a processing plant where biomass feedstocks are converted and/or extracted into a alternative energy nowadays. Biorefinery publication's most common nation was dominated by developed countries with a high human development index and a very supportive research ecosystem compared to developing countries like United States, China, Spain, United Kingdom, and Germany (World Population Review, 2021).

3.2 Most Frequent Affiliation of Biorefinery

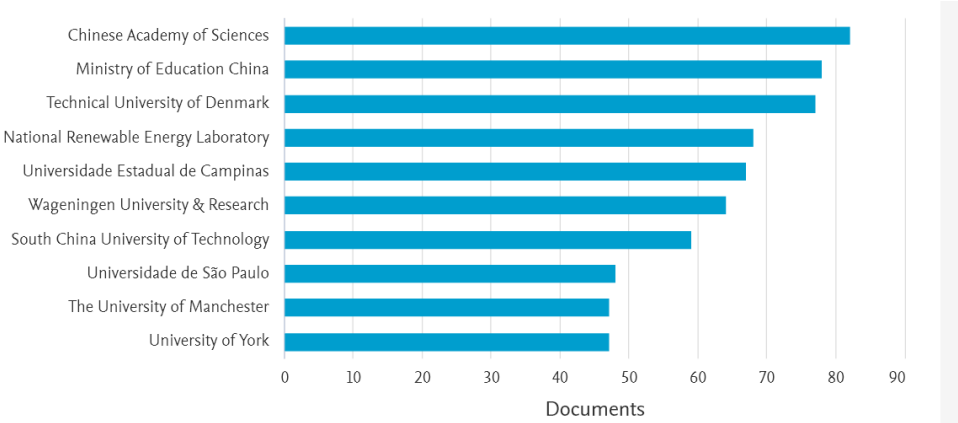

Figure 2. Affiliation Number of Biorefinery Per Year

There were 3.675 affiliated organizations that have researched Biorefinery. The higher organization that researches Biorefinery publications was The Chinese Academy of Sciences, China (n = 82). Then followed by the Ministry of Education China, China (n = 78), the Technical University of Denmark, Denmark (n = 77), National Renewable Energy Laboratory, USA (n = 68), Universidade Estadual de Campinas, Brazil (n = 67), Wageningen University & Research, Netherland (n = 64), South China University of Technology, China (n = 59), Universidade de São Paulo, Brazil (n = 48), The University of Manchester, United Kingdom (n = 47), University of York, USA (n = 47), Biorefinery research, in general, is carried outspread out by several countries and not dominated by one country. The Chinese Academy of Sciences, South China University of Technology & the Ministry of Education China. This is because the China was the country that supports development country.

3.3 Most Individual Authors of Biorefinery

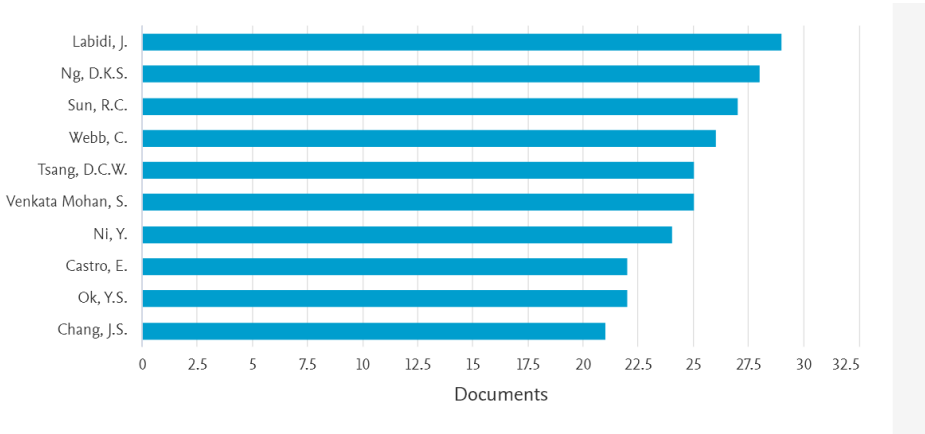

Figure 3. Most Individual Authors of Biorefinery

The author with the most research on Biorefinery was Labidi, Jalel, who is affiliated Universidad del Pais Vasco, Leioa, Spain (n = 29). Followed by Ng, Denny K.S, Heriot-Watt University Malaysia, Putrajaya, Malaysia (n = 28), Sun, Runchang, Dalian Polytechnic University, Dalian, China (n = 27), Webb, Colin, Department of Chemical Engineering and Analytical Science, Manchester, United Kingdom (n = 26), Tsang, Daniel C.W, Hong Kong Polytechnic University, Kowloon, Hong Kong (n = 25), Venkata Mohan, Srinivasula Reddy, Indian Institute of Chemical Technology, Hyderabad, India (n = 25), Then, Ni, Yonghao, Fujian Agriculture and Forestry University, Fuzhou, China (n = 24), Castro, Eulogio, Universidad de Jaén, Jaen, Spain (n = 22), Ok, Yong Sik, Korea University, Seoul, South Korea (n = 22), Chang, Jo-Shu, National Cheng Kung University, Tainan, Taiwan (n = 21), documents. Biorefinery research, in general, is carried outspread out by several countries and is not dominated by certain countries.

3.4 Most Frequent Type Document of Biorefinery

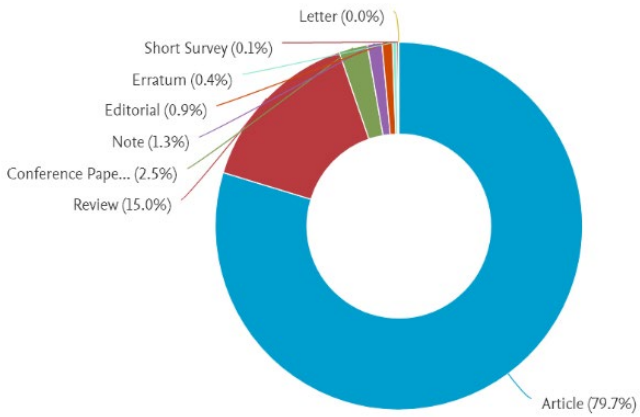

Figure 4. Most Frequent Type Document of Biorefinery

The most frequent type of documents in Biorefinery were Article 79.7% or (n = 2929), then Review 15.0% or (n = 553), Conference Paper 2.5% or (n = 92), Note 1.3% or (n = 47), Editorial 0.9% or (n = 34), Erratum 0.4% or (n = 14), Short Survey 0.1% or (n = 5), and letter 0.0% or (n = 1) documents.

3.5 Documents per year based on sources of Biorefinery

Table 1. Number of Documents Per Year Based on Sources of Biorefinery

No	Scientific Journal	Q/SJR	Article
1	Iop Conference Series Earth And Environmental Science	Q-/0.18	158
2	Sustainability Switzerland	Q2/0.33	58
3	E3s Web Of Conferences	Q-/0.2	49
4	Iop Conference Series Materials Science And Engineering	Q-/0.	35
5	Journal Of Cleaner Production	Q1/1.94	35

The number of documents per year by the source in international publications Biorefinery in was “Iop Conference Series Earth And Environmental Science” (n = 158) with Q- and 0.18 SJR. Followed by “Sustainability Switzerland” (n = 58) with Q2 and 0.33 SJR, “E3s Web Of Conferences” (n = 49) with Q- and 0.2 SJR, “Iop Conference Series Materials Science And Engineering” (n = 35) with Q- and 0. SJR, and “Journal Of Cleaner Production” (n = 35) with Q1 and 1.94 SJR.

3.6 Annual Documents from Biorefinery

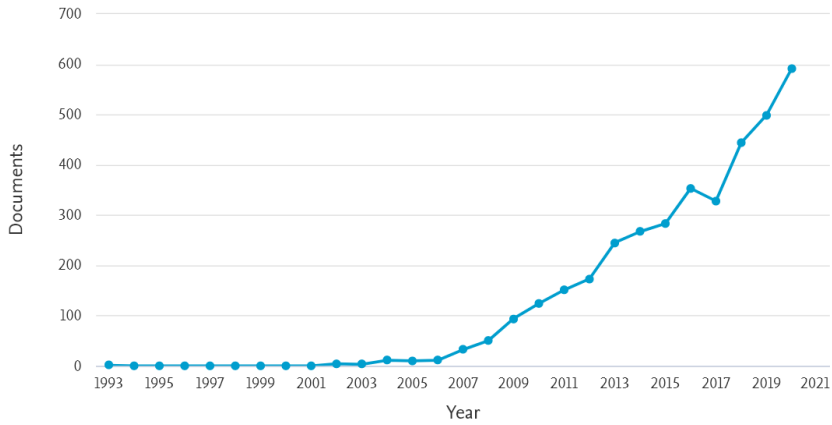

Figure 5. Number of Documents Per Year of Biorefinery

The number of Biorefinery publications at the international level has generally shown an increasing trend every year. This can be seen in Figure 5, the highest publication peak in 2020 with 592 documents. Biorefinery has been started since 1993. The number of documents per year published on Biorefinery is 499 documents in 2019, in 2018 there were 444 documents, in 2017 there were 328 documents, in 2016 there were 353 documents, and year 2015 there were 283 documents.

3.7 The document cited Biorefinery

Table 2. Citation quantity of Biorefinery

No	Document Title	Author	year	Source	Cited by
1.	"Biomass pretreatment: Fundamentals toward application"	Agbor, V.B., Cicek, N., Sparling. R., Berlin, A., Levin, D.B.	2011	Biotechnology Advances 29(6), pp 675-685	1142
2.	"Lignocellulosic biomass pyrolysis mechanism: A state-of-the-art review"	Wang, S., Dai, G., Yang, H., Luo, Z.	2017	Progress in Energy and Combustion Science 62, pp. 33-86	1018
3.	"Outlook for cellulase improvement: Screening and selection Strategies"	Percival Zhang, Y.-H., Himmel, M.E., Mielenz, J.R..	2006	Biotechnology Advances 24(5), pp. 452-481	1004
4.	"Trends in bioconversion of lignocellulose: Biofuels, platform chemicals & biorefinery concept"	Menon, V., Rao, M..	2012	Progress in Energy andCombustion Science 381(4), pp. 522-550	963
5.	"Lignin Depolymerization and Conversion: A Review of Thermochemical Methods"	Pandey, M.P., Kim, C.S.	2011	Chemical Engineering and Technology 34(W), pp. 29-41	942

The most cited Biorefinery as a form of academic impact is Agbor, V.B., Cicek, N., Sparling. R., Berlin, A., Levin, D.B. in 2011 entitled " Biomass pretreatment: Fundamentals toward application" cited by 1142 documents. The top 5 most cited publications are shown in Figure 6.

3.8 Keyword Network

The research theme map is a review that seeks to identify Biorefinery research based on keyword linkages between publications. The VOSViewer program was used to assess and visualize the development of the Biorefinery keyword scheme for the research theme map's Biorefinery. For the minimum number of keyword-related articles, threeten repetitions were required. As a result, 21.052 keywords out of 549 met the requirements.

Figure 6 represents eight research theme groups for the international academic publication of Biorefinery, which have been simplified and abbreviated as HCFB research themes, based on research keywords.

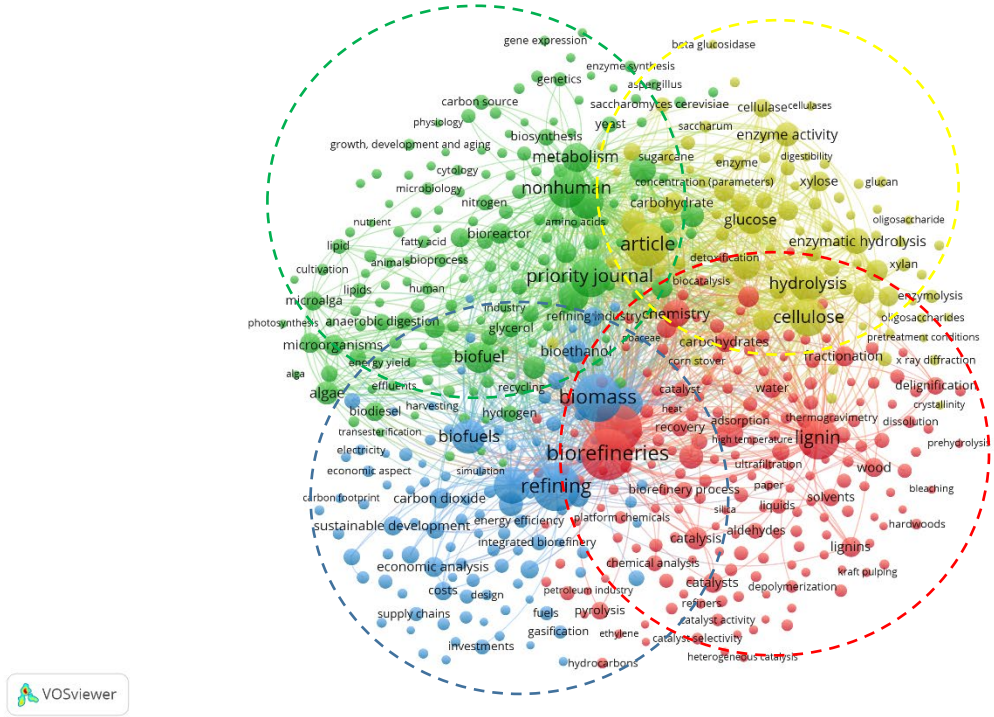

Figure 6. Keyword Network

1. Chemistry (Red). keywords such as acid, alcohol, alkalinity, bio oil, carbon, catalysts, charcoal, ethylene, formic acid, chlorine compounds. All these concepts are related to Chemistry.
2. Fermentation (Green). This cluster was dominated by the keywords such as alga, amino acid, aspergillus, bacteria, bacteriology, batch fermentation, fermentation, biological production, fungi, enzymology. All these concepts were related to Fermentation.
3. Biomass (Dark Blue). the keywords such as bio-energy, bioethanol, biofuels, biological material, biomass, bioproduct, distillation, energy, fuel, fossil fuel, and life-cycle. All these concepts are related to Biomass that dominated this cluster.
4. Hydrolysis (Yellow). the keywords such as alcohol, alkali, ammonia, bio ethanol production, cellulose, chemical composition, enzyme, glucose, hydrolysis, pre treatment, steam and waste, dominated this cluster.

3.9 Authorship Network

The criteria for the minimum number of documents per author were twenty five documents. Thus, from 10.115 authors, 11 authors have met the thresholds. There was a collaborative pattern of four groups between researchers at Biorefinery research Field as seen in Figure 7. The Green cluster contains Xueyan Chen, and Su Sun, they dominated by the same Affiliation University, College Station, Texas, United States of America. The Blue cluster contains Yan Zhang and Yikai Wang, they were dominated by the same country USA. Red cluster contains Yongzhuang Liu, Shouxin Liu and Tsang, Daniel C.W, they dominated by the same country China.

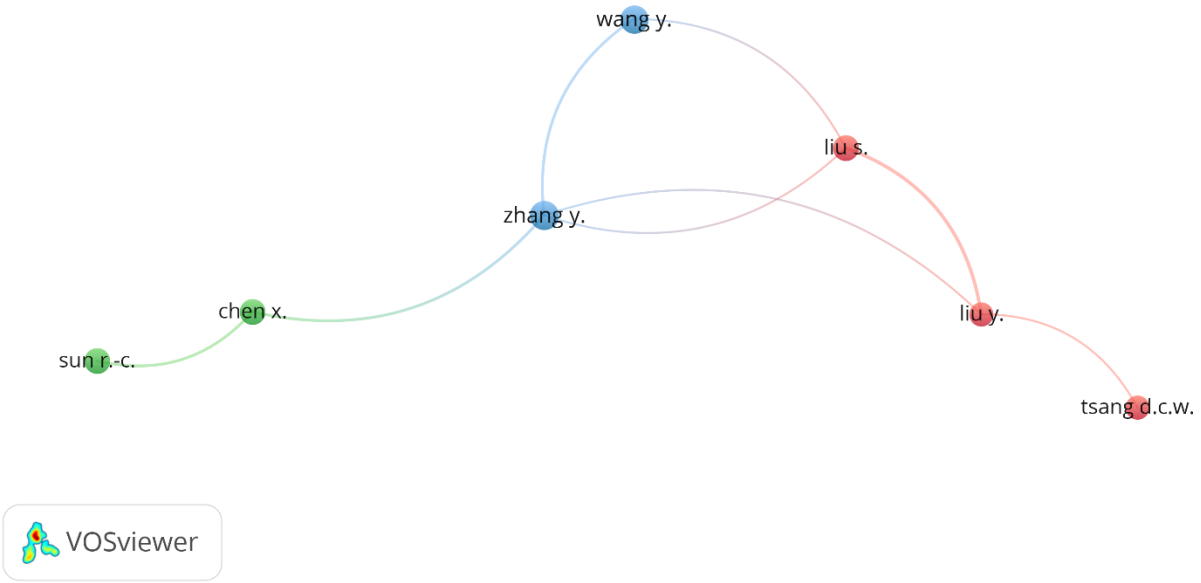

Figure 7 Authorship Network

4. CONCLUSION

According to the results, the number of international publications on the Biorefinery, as well as maps and visual patterns, has been increasing on an annual basis. The United States was the country that contributed the most to publications in Biorefinery research, with 749 articles. With 82 papers published in the Biorefinery publication, the Chinese Academy of Sciences, China was the most involved research institution. Labidi, Jalel was the researcher with the most writings in the field of Biorefinery publication, with 29 articles. The year 2020 saw the most academic publications in the Biorefinery research, with 592 papers published worldwide. The study Biorefinery as a form of academic impact is Agbor, V.B., Cicek, N., Sparling. R., Berlin, A., Levin, D.B. in 2011 entitled " Biomass pretreatment: Fundamentals toward application" cited by 1142 documents. The publishing of Biorefinery is related to Three researcher collaboration groups.

This research proposes a classification of the convergence axis, which includes research in the Biorefinery, to categorize the body of knowledge produced over the publication of Eight Teen years of academic research in terms of knowledge contributions: Hydrolysis, Chemistry, Fermentation, Biomass as HCFB themes. As a practical result of identifying key themes in the Biorefinery field, practical studies are required to clarify fundamental backgrounds and subjects, as well as study gaps, there is a clearer understanding of the need for them. All of this will assist in new research into the disciplines' lack of advanced expertise and analysis. The potential of a Biorefinery to contribute to sustainable development, Bio-Energy, and Renewable Energy are frequently studied themes

Acknowledgments

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Biographies

Andre Septianto is a junior researcher of the Chemical Engineering Department at the Universitas Nahdlatul Ulama Sidoarjo, Sidoarjo, Indonesia. Mr. Andre is a member of the Indonesian bibliometric research group managed by Agung Purnomo.

Elsa Rosyidah is head of the Institute for Research and Community Services and a faculty member of the Environmental Engineering Department at the Universitas Nahdlatul Ulama Sidoarjo, Sidoarjo, Indonesia. She earned an Associate of Agricultural Technology from IPB University, Indonesia; a Bachelor of Agricultural Technology in Agricultural Engineering from Brawijaya University, Indonesia; and a Master of Environmental Science from Universitas Padjadjaran, Indonesia. Mrs. Elsa is currently pursuing a Ph.D. in Environmental Engineering at Institut Teknologi Sepuluh Nopember, Indonesia. She is part of the 10,000 Women Entrepreneurship Partnership Global Cohort of The U.S. State Department, Goldman Sachs, & Thunderbird, School of Global Management. She has published several journals, books, and conference papers.

Agung Purnomo is a researcher and faculty member of the Entrepreneurship Department, BINUS Business School Undergraduate Program at the Bina Nusantara University, Malang Campus, Malang, Indonesia. He earned a Bachelor of Agriculture in Horticulture from Brawijaya University, Indonesia; and a Master of Business Administration in Creative and Cultural Entrepreneurship from Institut Teknologi Bandung, Indonesia. Mr. Agung is currently pursuing a Ph.D. in Management Science at Universitas Airlangga, Indonesia. He has published several journals and conference papers using bibliometric methods in collaboration with multidisciplinary researchers.