Journal of Engineering Science and Technology
20th EURECA 2023 Special Issue October (2024) 167 - 176

BIBLIOMETRIC ANALYSIS OF THE USE OF BIOCHAR IN AN ENVIRONMENTAL LAW PERSPECTIVE

ABRAHAM YAZDI MARTIN[1], MARTIN ROESTAMY[1], ASEP THOBIBUDIN QOLYUBI[1*], AAL LUKMANUL HAKIM[1], ASEP BAYU DANI NANDIYANTO[2]

[1]Universitas Djuanda, Jl. Tol Ciawi No. 1 16720, Indonesia
[2]Universitas Pendidikan Indonesia, Bandung, Indonesia
*Corresponding Author: thobibudin@unida.ac.id

Abstract

This research aims to examine the use of biochar from an environmental law perspective. This research method uses bibliometric analysis with three stages, namely harvesting data on Google Scholar using publish or perish, screening data in CSV format and visualization using VOSviewer. The research results show that the use of biochar as an alternative solution in reducing world carbon emissions and as an alternative solution in improving soil health, increasing plant growth and also being able to control pests and diseases must be ensured not to violate environmental laws and not endanger the environmental ecosystem. Therefore, further research is needed to ensure that biochar does not harm the environment and there must be detailed legal regulations governing the use of biochar.

Keywords: Biochar, Environmental, Law.

1. Introduction

Currently, the world is struggling with many environmental problems. As the population continues to grow, it is necessary to produce more food. The consequence of such a large demand for food is excessive soil fertilization, and often using uncontrolled and environmentally damaging methods. Biochar has the potential to change the world. As a type of charcoal classified under the "biomass with carbon removal and sequestration" (BiCRS) approach, biochar allows us to reduce emissions and lock up carbon permanently, making it crucial in the fight against climate change. Many research relating to biochar has been well-developed [1-3]

Unprecedented population growth and anthropogenic activities have generated large amounts of waste, depleted natural resources, excessive environmental pollution, and triggered climate change. Recently, biochar has emerged as an important tool to minimize the severity of this problem. Biochar is a carbon-containing solid material that is synthesized through heat treatment of biomass waste in a limited oxygen supply [4].

In recent years, biochar and its various possible applications have been widely investigated by researchers around the world [5]. Biochar can be utilized for energy purposes related to environmental conservation and agriculture. The various applications of biochar continue to grow, especially in industry, agriculture and operations related to the natural environment. It can be used as a soil additive, added to animal feed and silage, or applied in water treatment [6, 7]. Biochar can also be used for the immobilization of contaminants from soil, and waste processing; can be applied as an additive in composting and methane fermentation processes [8].

In Indonesia, biochar is often used in agriculture, namely, to improve soil health, increase plant growth and control pests and diseases. To increase food production to meet domestic needs and help the world overcome the food crisis, this is one of the main problems facing Indonesia currently. However, good productive land is limited and most of it has been utilized for food crop production or other uses [9]. Therefore, one of the biggest challenges of the 21st century is not only the production of environmentally safe and effective fertilizers but also their rational use and management. One solution is to use organic (natural) fertilizer with biochar.

Apart from all the benefits of biochar, what needs to be seen from another point of view is whether the process of making biochar can pollute the environment and what about environmental laws. This question needs to be raised so that every alternative solution that emerges with all its advantages and benefits must be in line with maintaining environmental sustainability. Such large-scale charcoal production would require hundreds of millions of hectares of land to produce biomass (most likely mainly tree plantations). This is an attempt to manipulate the biosphere and land use on a large scale to change the global climate, which makes it a kind of "geoengineering".

As is clear from the revealed dangers of agrofuels, such large-scale land conversion poses a major threat to biodiversity and ecosystems that plays a critical role in stabilizing and regulating the climate and is necessary to ensure food and water security. This threatens the livelihoods of many people, including Indigenous communities. The process of making charcoal and energy (pyrolysis) can produce dangerous land and air pollution and the impact of climate damage is irreversible.

This research aims to examine the use of biochar from an environmental law perspective. This research method used bibliometric analysis with three stages, namely harvesting data on Google Scholar using publish or perish, screening data in CSV format and visualization using VOSviewer. Bibliometric has been used and well-developed for understanding current research trend [10].

The research results show that the use of biochar as an alternative solution in reducing world carbon emissions and as an alternative solution in improving soil health, increasing plant growth and being able to control pests and diseases must be ensured not to violate environmental laws and not endanger the environmental ecosystem. Therefore, further research is needed to ensure that biochar does not harm the environment and there must be detailed legal regulations governing the use of biochar.

The novelty of this research is the need for detailed legal regulations governing the use of biochar to maintain biodiversity and environmental ecosystems.

2. Methods

Detailed information regarding how to use and analyze data using bibliometric is explained elsewhere [11-13]. The explanation in the present study is shown in the following sub-section.

2.1. Harvesting data

In this research, the author used the bibliometric analysis method using the Publish or Perish application by entering keywords on Google Scholar, namely "biochar, environmental, law" covering the period from 2018 to 2022 by limiting 200 articles with a total of 14,371 citations as shown in Fig. 1.

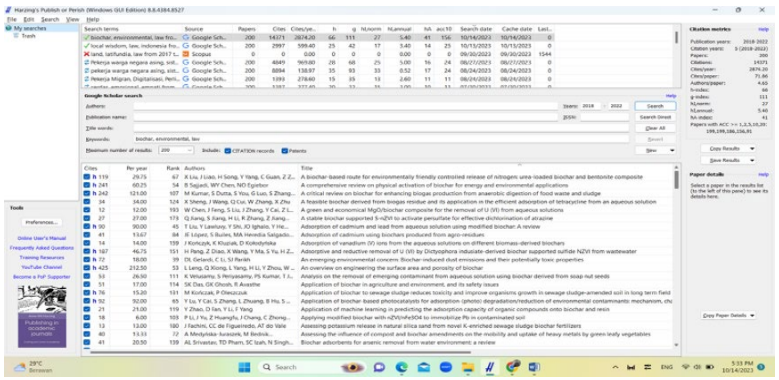

Fig. 1. Harzing's publish or perish.

2.2. Screening data

Data collected from Google Scholar is then saved in CSV format for screening according to the year of publication. The results of the screening in CSV format carried out in Microsoft Excel according to the year of publication, namely in 2018 there were 24 articles, in 2019 there were 42 articles, in 2020 there were 42 articles, in 2021 there were 42 articles and in 2022 there were 49 articles. Thus, the total

number of articles was 200 after screening according to the year of publication, there were 199 articles, and 1 article without a year of publication.

2.3. Data analysis and visualization

The data that has been selected and screened is then saved in RIS/Refmanager format for analysis using VOSviewer with a created map as shown in Fig. 2.

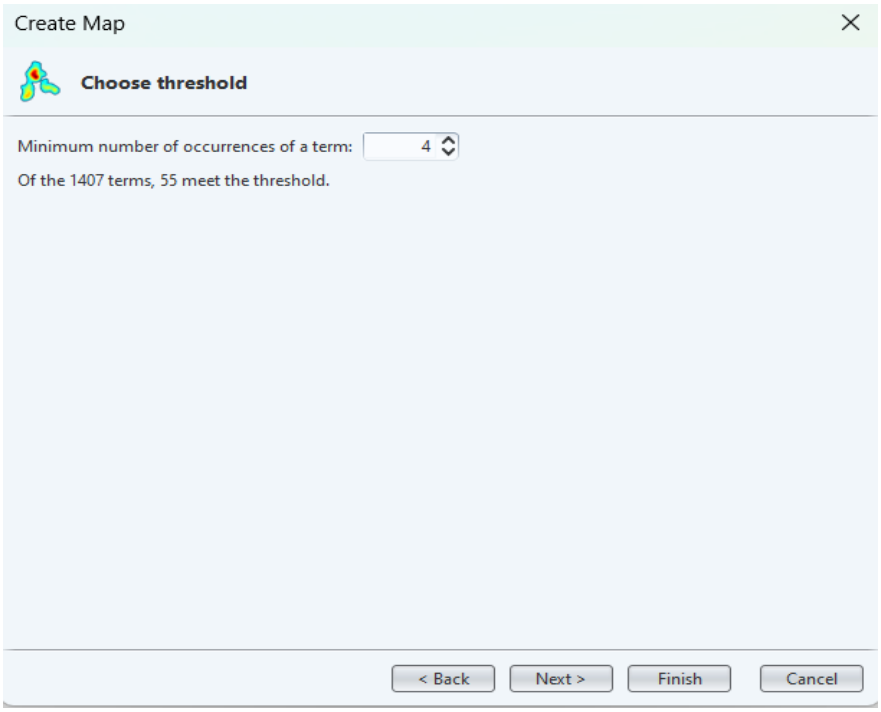

Fig. 2. Choose threshold.

3. Result and Discussion

3.1. Biochar character

The results of research by the Soil Research Institute provide information on several characteristics of the biochar produced, especially that which comes from agricultural waste raw materials. The amount of charcoal produced in one combustion ranges from 22.0-53.5% depending on the type of raw material used, combustion temperature and combustion equipment used. The duration of burning with the same combustion device results in different biochar production.

Biochar production from 4 types of agricultural waste at three burning times, namely 1.2 and 3.5 hours, resulted in differences in the percentage of biochar produced, percentage of ash, liquid smoke and water retention ability. The combustion tool used is a stainless kiln with a capacity of 40 L and a temperature of 250-3500 ℃. The highest biochar production was produced when burning for 3.5 hours for all types of agricultural waste, namely around 22.0-48.4%.

The wide application of biochar has driven biochar-related research and publications to multiply in the last decade. Bibliometric analysis can be performed concerning biochar and its applications, thus providing a better picture of the evolutionary trajectory of biochar research [14]. Bibliometric analysis implies statistical assessment of scientific publications and literature including research articles, review articles, books, book chapters, conference proceedings, etc. [15]. Bibliometric analysis is a powerful method to help researchers and analysts identify research trends and gaps to suggest/recommend adequate directions for future research [16].

Previously, bibliometric analysis was carried out using software such as Publish or Perish, CiteSpace, SciMAT, and VOSviewer which utilized different bibliographic databases (Science Citation Index, Scopus, and Web of Science), where: (i) analysed the role of emerging from the biochar system in the water-energy-food relationship through increased agricultural productivity resulting from increased soil fertility supported by biochar [17]; (ii) conducted bibliometric analysis on global research in the field of biochar [18]; (iii) investigated trends related to research into the remediation of contaminants from soil using biochar [19]; (iv) analyse research trends in biochar amendments to dry soils using bibliometric studies; (v) reviews biochar-related research and the evolving nature of biochar research in previous decades [20]; (vi) assessed bibliometric networks to determine the impact of biochar application on soil [21]; (vii) aims to provide insight into future research opportunities and prospects related to biochar; and the results of the search on the Vos Viewer machine along with a visualization of research trends in the biochar field for 2018 to 2022 as shown in Fig. 3.

Figure 3 depicts a visualization of the increasing trend in research on biochar from year to year. This illustrates that as time goes by biochar is increasingly popular and known to the public because of its benefits. For this reason, because there are more and more users, many researchers are interested in discussing and researching further about biochar, both in terms of its benefits and in terms of environmental law.

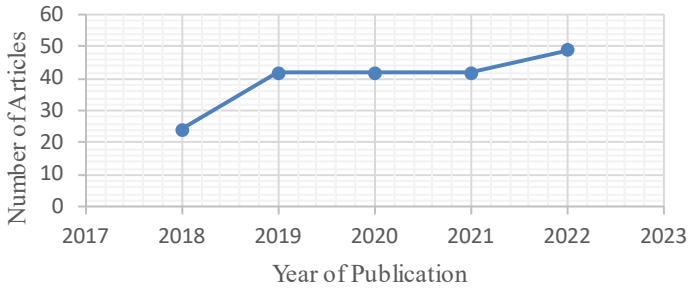

Fig. 3. Research trend.

3.2. Biochar from an environmental law perspective

Biochar is a term used to describe charcoal (usually finely powdered charcoal) added to soil. Biochar is produced through a process called biomass pyrolysis. This is done by exposing the biomass to high temperatures in the absence of oxygen.

This process produces two types of fuel (syngas or synthetic gas and vegetable oil) and charcoal as a by-product. These two types of fuel are only ideas from initiators who project biochar as an alternative solution for reducing world carbon emissions. What is clear is that the burning process still causes global warming, especially over an area of hundreds of millions of hectares.

REDD principles do not allow burning processes that cause pollution and damage the environment, especially in tropical forest areas. Natural forests must be maintained, protected and managed sustainably to ensure human life and the ecosystem within the forest. However, biochar legitimizes the burning that will occur in the clearing of large-scale monoculture plantations in the world such as sugar cane, palm oil, secondary crops and so on. What is clear is that industrial charcoal is waste, not an environmental saviour.

Biochar advocates promote a minimum “target” of using 500 million hectares or more to produce charcoal and energy. This land clearing is of course through a monoculture industrial plantation system where they will plant trees that grow quickly and can be processed to obtain charcoal and energy. Not only that, but the area of land needed is also to plant plants that supply the pulp and paper industry. Agrofuels have created severe social and environmental impacts, thereby worsening climate change. The enormous demand for new land for biochar will greatly make this problem even worse.

The danger is that natural forests and tropical forests will be renewed with industrial forest plantations which are of course monocultures to meet the demands of energy production.

Law Number 32 of 2009 concerning Environmental Protection and Management as amended by Law of the Republic of Indonesia Number 11 of 2020 concerning Job Creation in Article 98 which reads "Every person who deliberately carries out an act that results in exceeding the ambient air quality standards, standard water quality, seawater quality standards, or standard criteria for environmental damage, shall be punished with imprisonment for a minimum of 3 (three) years and a maximum of 10 (ten) years and a fine of at least IDR 3,000,000,000.00 (three billion rupiahs) and a maximum of IDR 10,000,000,000.00 (ten billion rupiah).”

If this biochar research still cannot be justified, it can be proven by other researchers who say that the results of biochar research are inconsistent, the use of biochar in soil can cause environmental pollution and the process of making biochar by burning can change air quality (air pollution) which can endanger human health, then it can fall under Article 98 of Law no. 11 of 2020.

Therefore, while the use of biochar has not yet reached a large-scale stage and become an industry that can harm the environmental ecosystem, the government is obliged to immediately make regulations governing the use of biochar, the government must even create a team to research the use of biochar. Thus, the alternative solutions taken still pay attention to environmental sustainability and do not harm society in the long term.

There is no consistent evidence that charcoal can make soil more fertile. As is the custom of Indigenous people in Tanah Papua, Indonesia, they usually cut down small areas of forest to plant food needs such as taro, tubers, and vegetables. Usually in the first year, from the burnt results in the new garden, the soil is very

fertile. In the second year, the soil humus has decreased. In the third year, the soil humus is no longer guaranteed. Thus, people have to leave old gardens and open new gardens in the fourth year. This means that the charcoal does not survive to restore soil humus. Industrial charcoal production at the expense of the organic substances needed to make humus can produce the opposite result.

A mixture of charcoal and fossil fuel-based fertilizer made by scrubbing exhaust gas from coal-fired power plants is being promoted as "biochar," and it will help perpetuate the burning of fossil fuels and emissions of nitrous oxide (N_2O), a greenhouse gas that causes dangerous. Therefore, before the use of biochar and production of biochar in large quantities occurs, it is particularly important to study it from an environmental law perspective, especially environmental law in Indonesia.

Based on the results of bibliometric analysis from screening data from Publish or Perish into VosViewer, the strength of the relationship between the keywords "biochar, environment, law" as shown in Figs. 4-6.

Figure 4 explains the results of network visualization analysis in VosViewer which shows 6 clusters consisting of Cluster 1 in red containing 7 items consisting of biochar, biochar production, biomass, energy, environmental application, environmental impact, and environmental management. Cluster 2 in green contains 4 items consisting of biochar yield, environmental risk, pyrolysis, and sewage sludge. Cluster 3 in blue contains 3 items consisting of biochar amendment, biochar application, and soil. Cluster 4 is yellow (leaf green) and contains 3 items consisting of environment, mechanism, and modified biochar. Cluster 5 is purple, there are 3 items consisting of agriculture, pyrolysis temperature, and temperature. And finally, in cluster 6, turquoise, there are 2 items consisting of law and regulation.

Of the 6 clusters above that have the lowest strength and occurrences, namely cluster 1 biochar, cluster 3 soil, cluster 4 environment and cluster 6 law, this illustrates that there is a strong relationship between biochar, soil, environment and law.

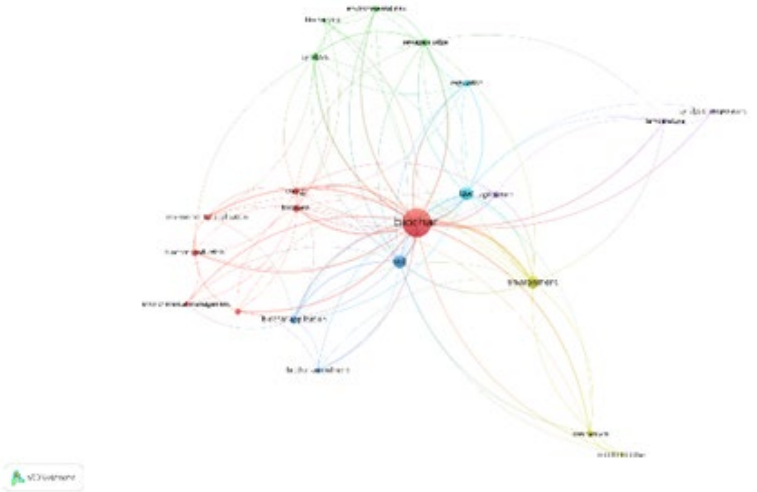

Fig. 4 Network visualization.

Figure 5 explains the year-on-year time trend regarding closely related topics from 2018 to 2022. Several colours appear in Fig. 5, the darker the colour in the visualization shows that the topic is research that has been studied for quite a long time, while the lighter it is. The colours in the visualization indicate the latest research. In the overlay analysis it can be found that the themes of biochar, environmental and law are included in the latest research.

Figure 6 explains the density visualization of the keywords biochar, environmental, and law. The density visualization shows that the brighter the colour that appears indicates that the topic is being widely researched, and the fainter the colour that appears indicates that the topic has not been widely researched. The light colour of biochar shows that the topic of biochar is being widely researched and the slightly darker colour of law and environmental issues is still not widely researched.

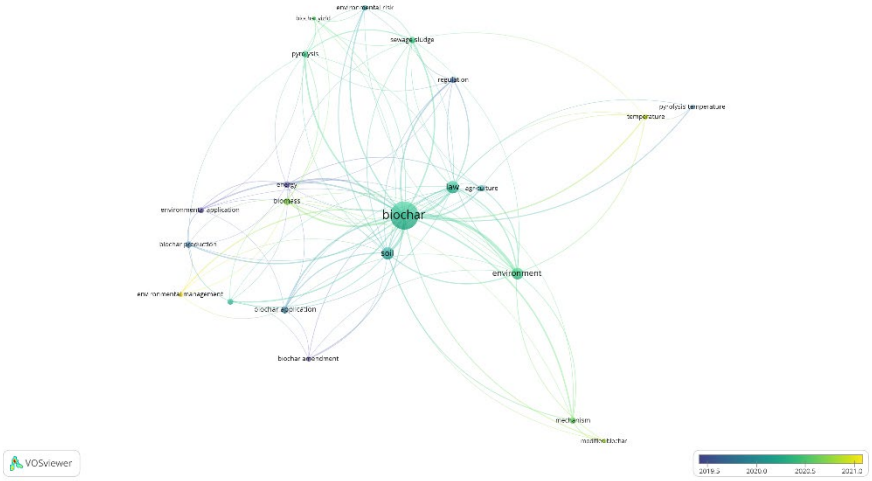

Fig. 5. Overlay visualization.

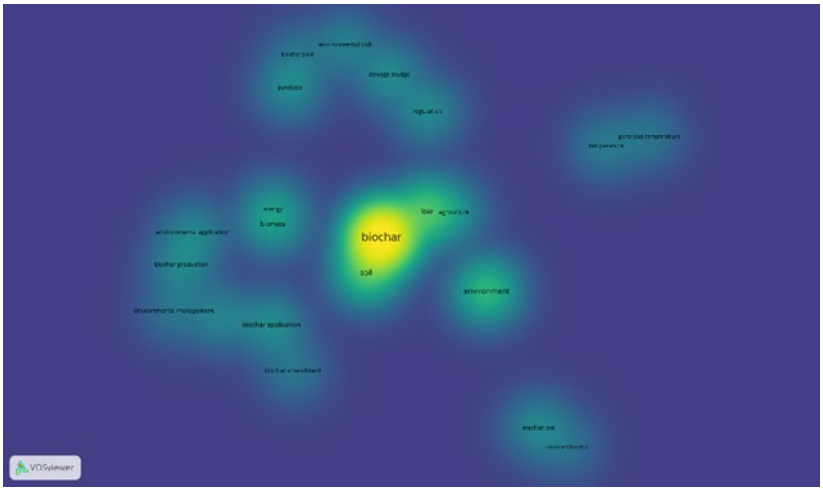

Fig. 6. Density visualization.

4. Conclusion

The use of biochar in the soil which is considered an alternative solution in reducing world carbon emissions and an alternative solution in improving soil health, increasing plant growth and being able to control pests and diseases must be ensured not to violate environmental laws and not endanger the environmental ecosystem. If you look at the process of making biochar and pay attention to the development of biochar use in the world, which requires land of up to 500 million hectares, this can threaten the environmental ecosystem, be it land, forests, water and the burning process can cause air pollution.

Therefore, further research is needed to ensure that biochar does not harm the environment and there must be legal regulations governing the use of biochar.

References

1. Nandiyanto, A.B.D.; Fiandini, M.; Ragadhita, R.; Maulani, H.; Nurbaiti, M.; Al-Obaidi, A.S.M.; Yunas, J.; and Bilad, M.R. (2023). Sustainable biochar carbon biosorbent based on tamarind (Tamarindusindica L) seed: Literature review, preparation, and adsorption isotherm. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 32(1), 210-226.
2. Nandiyanto, A.B.D.; Fiandini, M.; Fadiah, D.A.; Muktakin, P.A.; Ragadhita, R.; Nugraha, W.C.; Kurniawan, T.; Bilad, M.R.; Yunas, J.; and Al Obaidi, A.S.M. (2023). Sustainable biochar carbon microparticles based on mangosteen peel as biosorbent for dye removal: Theoretical review, modelling, and adsorption isotherm characteristics. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, 105(1), 41-58.
3. Ramdhani, M.R.; Kholik, A.; Fauziah, S.P.; Roestamy, M.; Suherman, I.; and Nandiyanto, A.B.D. (2023). A comprehensive study on biochar production, bibliometric analysis, and collaborative teaching practicum for sustainable development goals (SDGs) in islamic schools. *Jurnal Pendidikan Islam*, 9(2), 123-144.
4. Hossain, M.Z.; Bahar, M.M.; Sarkar, B.; Donne, S.W.; Ok, Y.S.; Palansooriya, K.N.; Kirkham, M.B.;Chowdhury, S.; and Bolan, N. (2020). Biochar and its importance on nutrient dynamics in soil and plant. *Biochar*, 2, 379-420.
5. Saletnik, B.; Zaguła, G.; Bajcar, M.; Tarapatskyy, M.; Bobula, G.; and Puchalski, C. (2019). Biochar as a multifunctional component of the environment-A review. *Applied Sciences*, 9(6), 1139.
6. Malińska, K. (2015). Legal and quality aspects of requirements defined for biochar. *Inżynieria i Ochrona Środowiska*, 18, 359-371.
7. Pereira, R.C.; Muetzel, S.; Arbestain, M.C.; Bishop, P.; Hina, K.; and Hedley, M. (2014). Assessment of the influence of biochar on rumen and silage fermentation: A laboratory-scale experiment. *Animal Feed Science and Technology*, 196, 22-31.
8. Tang, J.; Zhu, W.; Kookana, R.; and Katayama, A. (2013). Characteristics of biochar and its application in remediation of contaminated soil. *Journal of Bioscience and Bioengineering,* 116(6), 653-659.
9. Masulili, A.; Utomo, W.H.; and Syechfani, M.S. (2010). Rice husk biochar for rice based cropping system in acid soil 1. The characteristics of rice husk

biochar and its influence on the properties of acid sulfate soils and rice growth in West Kalimantan, Indonesia. *Journal of Agricultural Science*, 2(1), 39-47.

10. Soegoto, H.; Soegoto, E.S.; Luckyardi, S.; and Rafdhi, A.A. (2022). A bibliometric analysis of management bioenergy research using vosviewer application. *Indonesian Journal of Science and Technology*, 7(1), 89-104.
11. Al Husaeni, D.F.; and Nandiyanto, A.B.D. (2022). Bibliometric using VOSviewer with publish or perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post covid-19 pandemic. *ASEAN Journal of Science and Engineering*, 2(1), 19-46.
12. Qolyubi, A.T.; Roestamy, M.; and Martin, A.Y. (2023) digitalization of land measurement map to minimize land dispute. *Journal of Engineering Science and Technology,* 18(3), 57-64
13. Roestamy, M.; Martin, A.Y.; & Qolyubi, A.T. (2023) Digitizing Land Registration As An Effort To Minimize The Practice Of The Land Mafia. *Journal of Engineering Science and Technology*, 18(3),73-80
14. Abdeljaoued, E.; Brulé, M.; Tayibi, S.; Manolakos, D.; Oukarroum, A.; Monlau, F.; and Barakat, A. (2020). Bibliometric analysis of the evolution of biochar research trends and scientific production. *Clean Technologies and Environmental Policy*, 22(10), 1967-1997.
15. Arfaoui, A.; Ibrahimi, K.; and Trabelsi, F. (2019). Biochar application to soil under arid conditions: a bibliometric study of research status and trends. *Arabian Journal of Geosciences*, 12(2), 1-9.
16. Sossa, C.L.G.; Sanogo, S.; Naab, J.B.; and Sintondji, L.O. (2022). Trends and research features on greenhouse gas emissions from rice production: review based on bibliometric analysis. *Environmental Science and Pollution Research,* 29(49), 73828-73841.
17. Belmonte, B.A.; Benjamin, M.F.D.; and Tan, R.R. (2017). Biochar systems in the water-energy-food nexus: the emerging role of process systems engineering. *Current Opinion in Chemical Engineering,* 18*,* 32-37.
18. Ahmed, A.S.F.; Vanga, S.; and Raghavan, V. (2018). Global bibliometric analysis of the research in biochar. *Journal of Agricultural & Food Information,* 19(3), 228-236.
19. Zama, E.F.; Reid, B.J.; Arp, H.P.H.; Sun, G.-X.; Yuan, H.-Y.; and Zhu, Y.-G. (2018). Advances in research on the use of biochar in soil for remediation: a review. *Journal of Soils and Sediments*, 18(7), 2433-2450.
20. Li, D. et al. (2020). Biochar-related studies from 1999 to 2018: a bibliometrics-based review. *Environmental Science and Pollution Research*, 27(3), 2898-2908.
21. Yan, T.; Xue, J.; Zhou, Z.; and Wu, Y. (2020). The trends in research on the effects of biochar on soil. *Sustainability*, 12(18), 7810.