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# Research Trends from The Scopus Database Using Keyword Water Hyacinth and Ecosystem: A Bibliometric Literature Review

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## ABSTRACT

The problem of water hyacinth (*Eichhornia crassipes*) invading aquatic biota ecosystems is a hot issue that is currently being discussed throughout the world. Due to the many solutions proposed in academia for their management, mitigation, and utilization, it is necessary to investigate through systematic research. Based on this, this study aims to present research developments on the topic of water hyacinths and ecosystems using bibliometric analysis. In this research, a total of 227 articles from 2000 to 2023 years regarding the keywords “water hyacinth” AND “ecosystem” were taken from Scopus which was used for further analysis. To accomplish the bibliometric analysis, the software programs VOSviewer was used. Based on the findings, it shows that the number of article publications over the last 23 years (2000-2023) has experienced fluctuating changes which are divided into three periods. The pioneering and growth periods were identified in 2000-2008 and 2009-2015. Meanwhile, the acceleration period will occur in 2016-2023. According to the results of data visualization, it was found that there were 4 clusters. The keyword "water hyacinth" is used more frequently, especially in 2016. The most productive affiliate publishing article is the University of California. Meanwhile, the most productive country is India. In addition, most productive authors come from India, namely Kanna, S. and Dube, T.



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## 1. INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is an aquatic plant that can grow quickly in the tropics. An ecosystem is a type of ecological system that is generated by an unbreakable reciprocal interaction between living creatures and their surroundings. Water hyacinth plants can adapt well thus and they spread very quickly (Duruin *et al*., 2022). Due to the high speed of spreading water hyacinth, this plant is considered an invasive plant that can damage the aquatic ecosystem's environment (Degaga, 2018; Glushchenko, 2022). In addition, water hyacinth can also cause increased evapotranspiration (evaporation and loss of water through plant leaves) because of its wide leaves and fast growth (Yan *et al*., 2017). The decrease in the amount of light entering the waters causes a decrease in the level of solubility of oxygen in water (DO: Dissolved Oxygens) (Glupta & Yadav, 2020). Even dead water hyacinth plants are very disturbing because they will sink to the bottom of the waters, accelerating the silting process (Du *et al*., 2020). These conditions require efforts to utilize water hyacinth plants in value-added products. This is because the water hyacinth plant is abundant and has a high content of 20% cellulose, 48% hemicellulose, and 3.5% lignin thus it can be explored into various value-added products (Bote *et al*., 2020; Duruin *et al*., 2022).

Many studies have reported various efforts made to overcome the problem of water hyacinth which damages aquatic ecosystems by utilizing it in various value-added products, such as livestock (Hu *et al*., 2020), biochar (Yu *et al*., 2018), briquettes (Rezania *et al*., 2016), fertilizers (Arutselvy *et al*., 2021), biogas (Tasnim *et al*., 2017), phytoremediation (Ting *et al*., 2018), bioplastics (Syafri *et al*., 2019), bioenergy (Huang *et al*., 2020), and enzymes (Malar *et al*., 2016). Not only that product but water hyacinth can also be used as an adsorbent to overcome water pollution caused by industrial and household waste because it has an extraordinary absorbing ability (Priya & Selvan, 2017). These various efforts have different steps to overcome the water hyacinth problem which are discussed clearly and completely and show successful management for a sustainable future. Additionally, a lot of research has concentrated on reducing the financial expenses associated with turning water hyacinths into different goods with additional value (Harun *et al*., 2021; Bhattacharya *et al*., 2015).

Consequently, the purpose of this research is to present research developments on the topic of water hyacinths and ecosystems using bibliometric analysis. Bibliometric analysis techniques use mathematics and statistics to evaluate quantitatively in observing certain studies. There are many studies regarding the use of bibliometric analysis (Al Husaeni & Nandiyanto, 2023; Bilad, 2022; Fauziah & Nandiyanto, 2022; Mudzakir et al., 2022; Mulyawati et al., 2021; Nandiyanto et al., 2023; Nandiyanto & Al Husaeni, 2021; Nandiyanto & Al Husaeni, 2022; Nandiyanto et al., 2020; Nandiyanto et al., 2022; Nordin, 2022; Nugraha & Nandiyanto, 2022; Ragahita & Nandiyanto, 2022; Setiyo et al., 2021; Shidiq, 2023; Soegoto et al., Sudarjat, 2023; Wiendartun et al., 2022; Wirzal & Putra, 2022; Utama et al. 2023; Husain et al., 2023; Sahidin et al., 2023; Al Husaeni & Munir, 2023; Al Husaeni, 2022; Firdaus et al., 2023; Santoso et al., 2022; Ruzmetov & Ibragimov, 2023). We believe that this study can give additional information regarding the research trend.

The most common aspects of bibliometric analysis are publication classification, author, subject area, title, year, document source, and citations. In addition, in this research bibliometric analysis used VOSviewer which presents network, overlay, and density mapping in a complete and clear. The novelty of this research includes a better understanding of the challenges and opportunities for developing research on the topic of water hyacinth and ecosystem. This is very important in determining the accuracy of future research gaps.

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Hopefully, this research can help and become a reference for other researchers who will research the topic of water hyacinths and ecosystems.

## 2. METHODS

This research examined and mapped the development of the water hyacinth topic using bibliometric analysis. The article data in this research were obtained from the Scopus database (https://scopus.com/). The data collection steps in this research are presented in **Figure 1**. The description of the data collection steps is described as follows:

(i) Determine the keywords "water hyacinth" AND "ecosystem" with categories of titles, articles, abstracts, years, keywords, authors, number of citations, and document sources from 2000 to 2023 used to search for articles from Scopus, especially those that are indexed Scopus.

(ii) The search results found 227 articles containing titles, number of publications per year, year of publication, number of citations, authors, and document sources saved in *RIS and *CSV formats.

(iii) Screening results in data from Scopus were carried out using Microsoft Excel 2019 software to analyze data on the number of publications per year, the highest number of citations, and the number of document sources that published many articles.

(iv) Data visualization was carried out using VOSviewer software to analyze the development trend of keywords (clusters) and analysis of frequently appearing article authors. In this research, the visualization results from VOSviewer consist of three mappings, namely, network, overlay, and density. In our earlier works (Al Husaeni & Al Husaeni, 2022; Al Husaeni & Nandiyanto, 2022; Al Husaeni & Al Husaeni, 2023), we provide comprehensive information about VOSviewer and library quest.

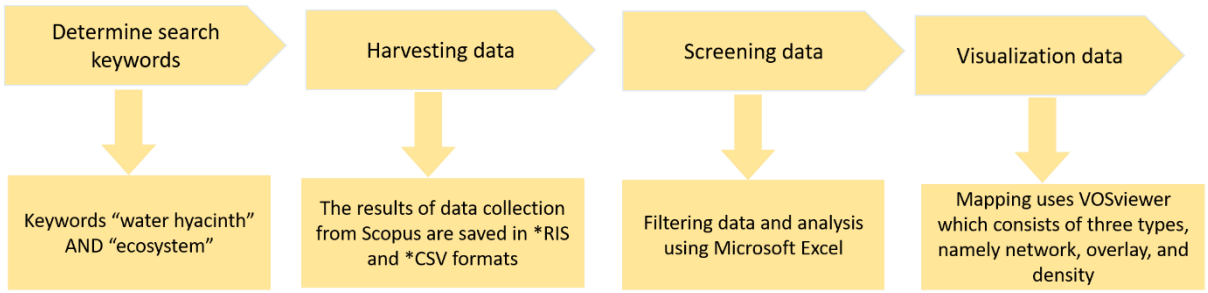


**Figure 1.** Step-by-step bibliometric analysis data collection.

## 3. RESULTS AND DISCUSSION

### 3.1. The development of research using keywords water hyacinth and ecosystem

**Figure 2** presents data on the development of research using keywords water hyacinths and ecosystem from the Scopus database for 23 periods (2000-2023). As presented in **Figure 2**, the development of research on the topic of water hyacinths has fluctuated over the last 23 years (2000-2023). The number of articles from 2000 to 2003 continued to increase by 1, 2, 4 and 7, respectively. In 2004 it was reduced by 3 articles. The increase in the number of articles occurred in 2005 and 2006 by 5 and 6 articles, respectively. In 2007 and 2008 there was a constant state of published articles, each of which was 8 articles. However, in 2009 the number of articles decreased to 4. The increase in the number of articles occurred in 2010 as many as 6 articles while in 2011 the number of articles decreased to 3. The number of articles increased to 10 in 2012. However, in 2013 and 2014 the number of articles decreased to 9

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and 3 articles, respectively. In 2015, the number of articles increased by 13. Meanwhile, the number of articles decreased to 12 articles in 2016. The number of articles increased by 19 in 2017. In 2018 there was a decrease in the number of articles by 9. In 2019 the number of articles increased to 18 yet decreased in 2020 to as many as 16. The increase in articles occurred in 2021 and 2022 to 22 and 27, respectively. However, in 2023 there was a decrease in articles by 12. The number of articles increased by 19 in 2017. The decrease in the number of articles occurred in 2018 to 9 articles. In 2019 the number of articles increased to 18 yet and decreased in 2020 to 16 articles. The increase in articles occurred in 2021 and 2022 to 22 and 27. However, in 2023 there was a decrease in articles of 12.

Based on the findings of the results database Scopus, the development period is divided into three periods, namely the pioneering, the growth, and the acceleration period. The first period is characterized by a low number of annual articles in the absence of a distinct trend. The third phase is characterized by a sudden exponential boom in growth observed every year (Song & Wang, 2020). In this case, the research pioneering period (from 2000 to 2008) and growth period (from 2009 to 2015) can be identified. Interestingly, 2016 to 2023 is entering a period of acceleration which can be seen from indications of growth in the first period, but it has not yet been fully realized. This is because, at the time of acceleration, there is pain in the water hyacinth which must be seen as a problem and is still being studied further using a new approach to using water hyacinth (Kartamihardja *et al.,* 2022).

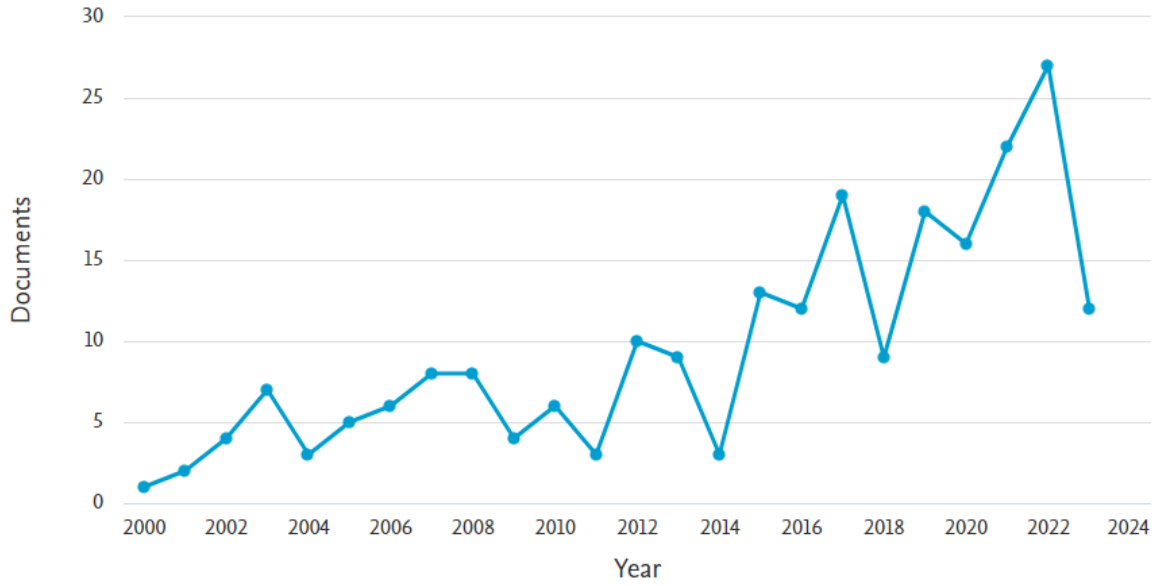


**Figure 2.** Level of the progress of research using keywords water hyacinth and ecosystem.

### 3.2. Top 10 most cited articles based on keywords water hyacinth and ecosystem

**Table 1** displays the 10 most cited articles. According to the data in **Table 1**, articles with the most citations were published in 2008, 2020, 2010, and 2017. Articles published in 2008 received the most citations, namely 283. This indicates that articles from that year are often used as reference sources in other citations.

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**Table 1**. Top 10 most cited articles using keywords water hyacinth and ecosystem

| No. | Authors | Title | Year | Total Citation | Ref. |
|---|---|---|---|---|---|
| 1 | Hestir E.L, Khanna S, Andrew M.E, Santos M.J, Viers J.H, Greenberg J.A, Rajapakse S.S, Ustin S.L. | Identification of invasive vegetation using hyperspectral remote sensing in the California Delta ecosystem | 2008 | 283 | Hestir *et al., (*2008) |
| 2 | Ali S, Abbas Z, Rizwan M, Zaheer I.E, Yavas I, Ünay A, Abdel-Daim M.M, Bin-Jumah M, Hasanuzzaman M, Kalderis D. | Application of floating aquatic plants in phytoremediation of heavy metals polluted water: A review | 2020 | 187 | Ali *et al.,* (2020) |
| 3 | Mishra V.K, Upadhyaya A.R, Pandey S.K, Tripathi B.D. | Heavy metal pollution induced due to coal mining effluent on the surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes | 2008 | 175 | (Mishra *et al.,* 2008) |
| 4 | Mahamadi C, Nharingo T. | Competitive adsorption of $Pb^{2+}$, $Cd^{2+}$, and $Zn^{2+}$ ions onto Eichhornia crassipes in binary and ternary systems | 2010 | 152 | Mahamadi and Nharingo (2010) |
| 5 | Saha P, Shinde O, Sarkar S. | Phytoremediation of industrial mines wastewater using water hyacinth | 2017 | 123 | Saha *et al.,* (2017) |
| 6 | Masifwa W.F, Twongo T, Denny P. | The impact of water hyacinth, Eichhornia crassipes (Mart) on the abundance and diversity of aquatic macroinvertebrates along the shores of northern Lake Victoria, Uganda | 2001 | 110 | Masifwa *et al.,* (2001) |
| 7 | Njiru M, Okeyo-Owuor J.B, Muchiri M, Cowx I.G. | Shifts in the food of Nile tilapia, Oreochromis niloticus (L.) in Lake Victoria, Kenya | 2004 | 107 | *Njiru et al.,* (2004) |
| 8 | Sarkar S, Paramanick M, Goswami S.B. | Soil temperature, water use, and yield of yellow sarson (Brassica napus L. var. glauca) concerning tillage intensity and mulch management under rainfed lowland ecosystem in eastern India | 2007 | 98 | Sarkar *et al*., (2007) |
| 9 | Goswami L, Nath A, Sutradhar S, Bhattacharya S.S, Kalamdhad A, Vellingiri K, Kim K.-H. | Application of drum compost and vermicompost to improve soil health, growth, and yield parameters for tomato and cabbage plants | 2017 | 97 | Goswami *et al.,* (2017) |
| 10 | Alagu K, Venu H, Jayaraman J, Raju V.D, Subramani L, Appavu P, S D. | Novel water hyacinth biodiesel as a potential alternative fuel for existing unmodified diesel engine: Performance, combustion and emission characteristics | 2019 | 97 | Alagu *et al.,* (2019) |

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### 3.3. Top most based on affiliates, authors, and countries using keywords water hyacinth and ecosystem

From the search results of the Scopus database shown in **Figure 3**, the top 15 affiliates were found using the keywords water hyacinth and ecosystem. Based on **Figure 3,** the most affiliated compilation of articles with the keywords water hyacinth and ecosystem is from the University of California and Chinese academic sciences with 7 articles each. **Figure 4** and **Figure 5** are the most productive findings based on the author and the country of publication of the article with the keywords water hyacinth and ecosystem. According to the data in **Figure 4**, it can be seen that there are 10 most productive countries. India is the most productive country compared to 9 other countries with a total of 40 articles. This is also supported by the data in **Figure 5**, the authors from India namely Kanna, S. and Dube, T. are the most productive with many articles of 4 and 3, respectively.

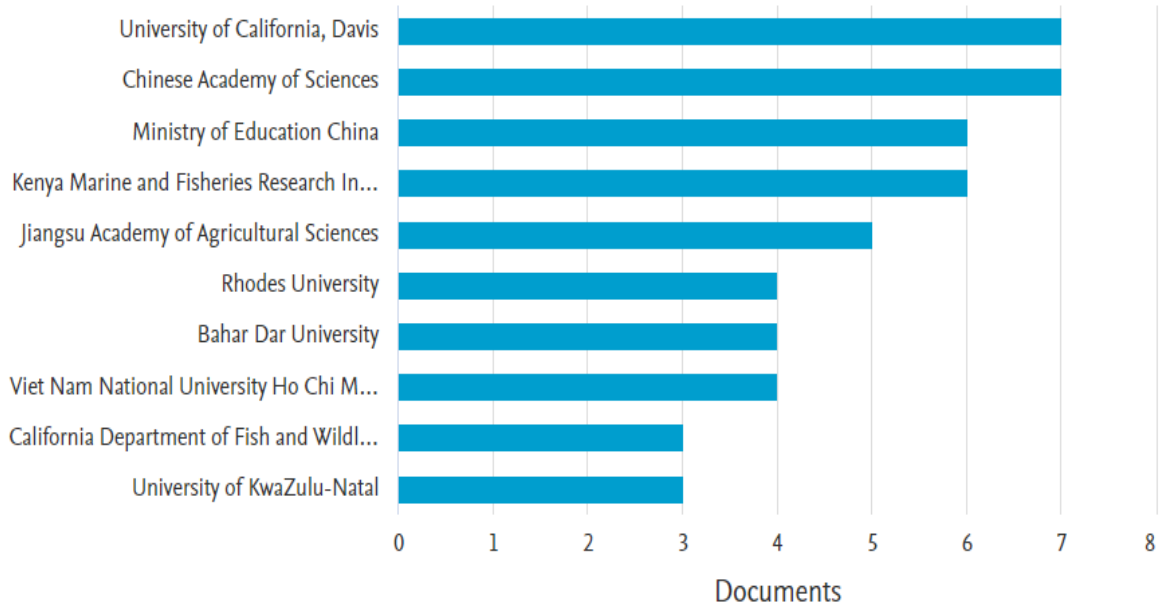


**Figure 3.** The most productive top affiliates use keywords water hyacinth and ecosystem.

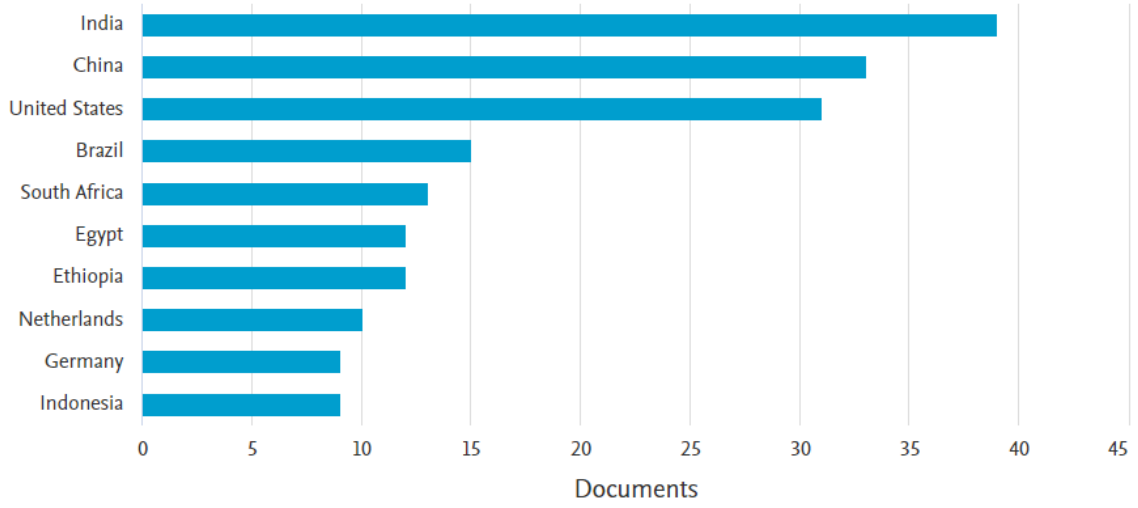


**Figure 4.** The most productive top country using keywords water hyacinth and ecosystem.

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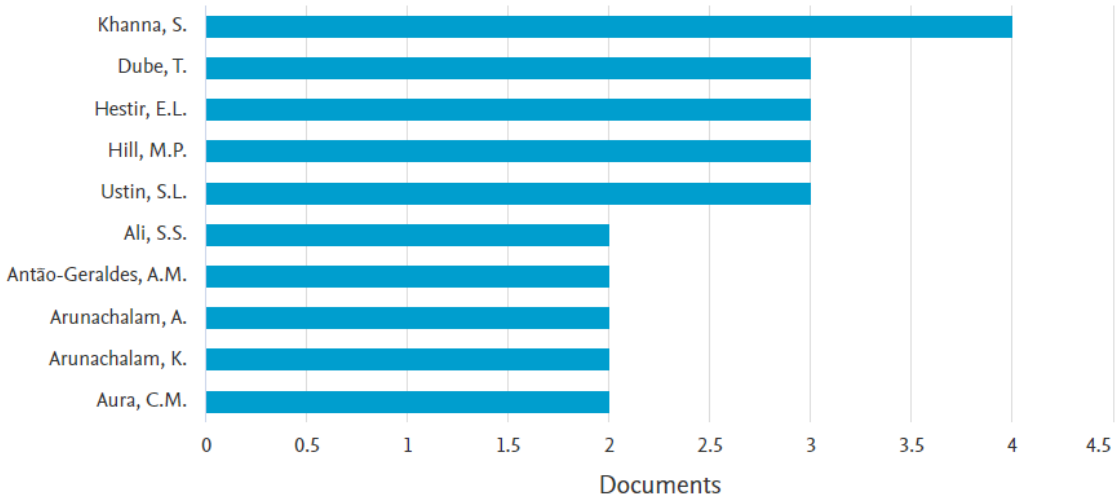


**Figure 5.** The most productive top authors used the keywords water hyacinth and ecosystem.

### 3.4. Visualization keyword water hyacinth and ecosystem using VOSviewer

To use VOSviewer, there must be a minimum of 10 associations between terms. Following analysis with VOSviewer, there were four clusters (red, green, blue, and yellow), which illustrate the connections between various topics. (see **Table 2**). Three distinct renderings of bibliometric mapping are available in VOSviewer, there are Network visualization (**Figure 6**), overlay visualization (**Figure 7**), and density visualization (**Figure 8**) (Hamidah *et al*., 2020; Al Husaeni *et al*., 2023; Nandiyanto *et al*., 2021; Hofifah & Nandiyanto, 2024). The keywords utilized in this study are indicated by colored circles. The circle's size is inversely associated with the frequency of keywords in abstracts and titles. As a result, the frequency of occurrences determined the size of the letters and circles. The size of the letters and circles increases when a keyword is used more frequently (Maryanti *et al*., 2023). Extraction results from titles, keywords, and abstracts found 227 documents (2000 – 2023). The data used is only Scopus-indexed article data.

**Figure 6** shows the clusters in each of the topic areas studied. It can be seen that the keywords "water" AND "water hyacinth" AND "ecosystem" are in different groups. Water hyacinth is in cluster 4 which is marked in yellow with a total of 113 links and 2858 Total Strength Links. In addition, water hyacinth has 188 occurrences (see **Figure 9**). While the keyword ecosystem is in Cluster 3 with a total of 112 links, 1362 Total Link Strength, and 87 occurrences (see **Figure 10**). **Figure 10** shows the trend from year to year related to this research (Hamidah *et al*., 2020). Based on **Figure 7**, the keywords used were often researched in 2016. Meanwhile, **Figure 7** shows the depth of the research, answering the darker the color that appears and the number of studies increasing.

As shown in **Figures 6 – 8**, it can be seen that the keyword water hyacinth is still often used for research, but for the keyword ecosystem, although both are still researched frequently, especially in 2016, it is no more frequent than the keyword water hyacinth. Water hyacinth has been extensively researched because this plant is one of the plants that can become a pest that can hamper aquatic ecosystems. Water hyacinth can cause oxygen levels in the water to drop drastically because at night it does respiration by inhaling oxygen. In addition, water hyacinth is easy to find, especially in areas that have many shallow ponds, wetlands and swamps, slow-flowing water, lakes, water reservoirs, and rivers (Jafari, 2010).

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**Table 2**. VOSviewer cluster results.

| No | Items | Color | Items |
|---|---|---|---|
| 1 | 41 | Red | Ability, aquatic ecosystem, aquatic environment, aquatic macrophyte, aquatic plant, concentration, condition, day, e-crassipe, eutrophication, experiment, function, growth, heavy metal, leafe, macrophyte, mart, mg l, nitrogen, nutrient, order, oxygen, phosphorus, phytoremediation, plant, pollutant, process, reduction, removal, response, role, root, solm, system, temperature, time, treatment, wastewater, water, water body, water lettuce. |
| 2 | 31 | Green | Abundance, area, biodiversity, change, distribution, diversity, effect, euchronia, crassipe, environment, extent, fish, freshwater ecosystem, habitat, hyacinth, impact, importance, increase, invasion, invasive plant, invasive species, lake Victoria, number, population, presence, region, site, species, spread, study, water quality, year. |
| 3 | 23 | Blue | Analysis, case, data, ecosystem, ecosystem service, Ethiopia, factor, lake, management, model, need, present study, proliferation, sample, sediment, solid, study area, surface, total, total nitrogen, total phosphorus, value, wetland. |
| 4 | 19 | Yellow | Addition, application, approach, biomass, control, cost, decade, lack, paper, part, problem, production, research, resource, river, use, water hyacinth, weed, world. |

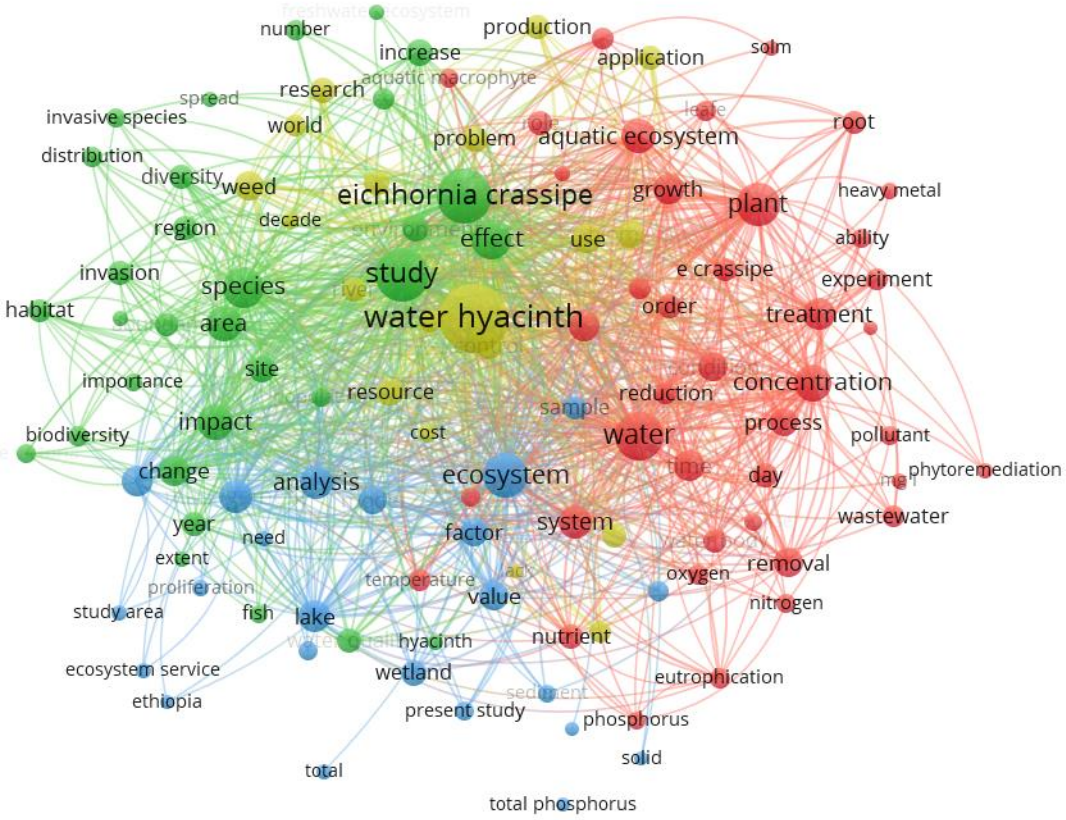


**Figure 6**. Network visualization based on co-word.

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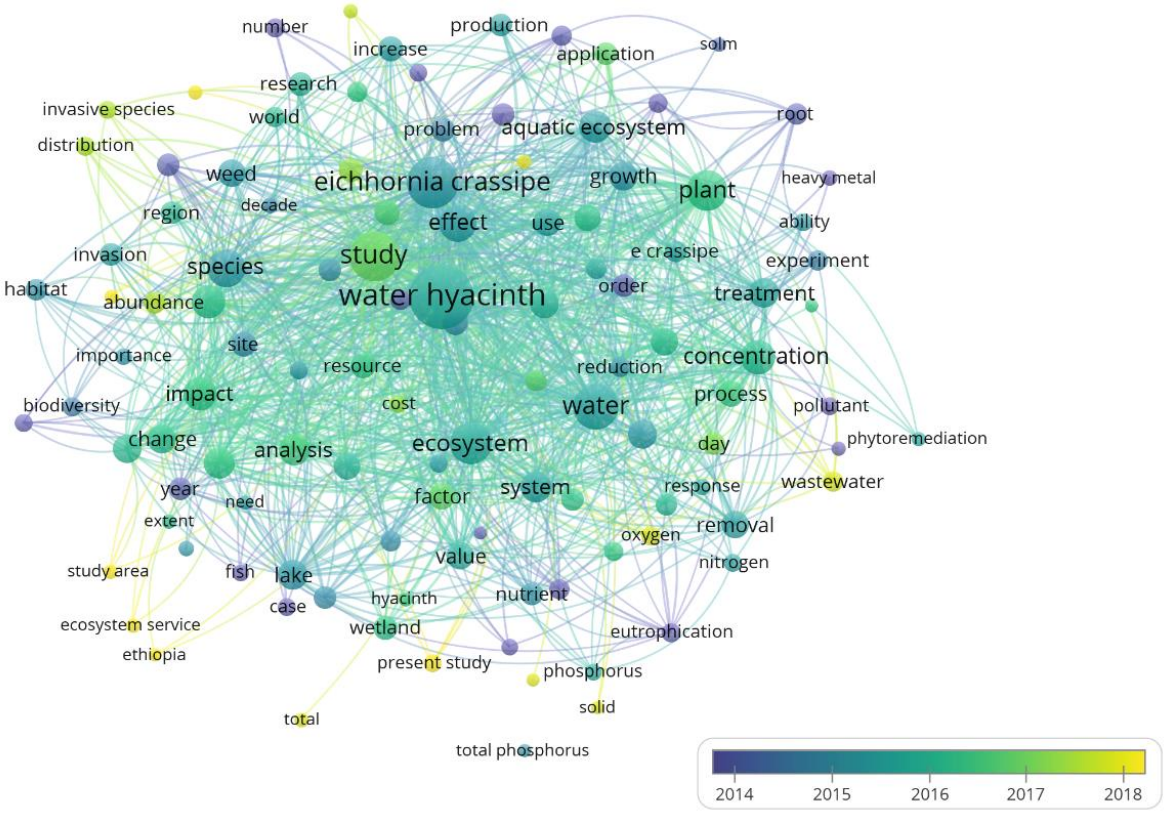


**Figure 7**. Overlay visualization based on co-word.

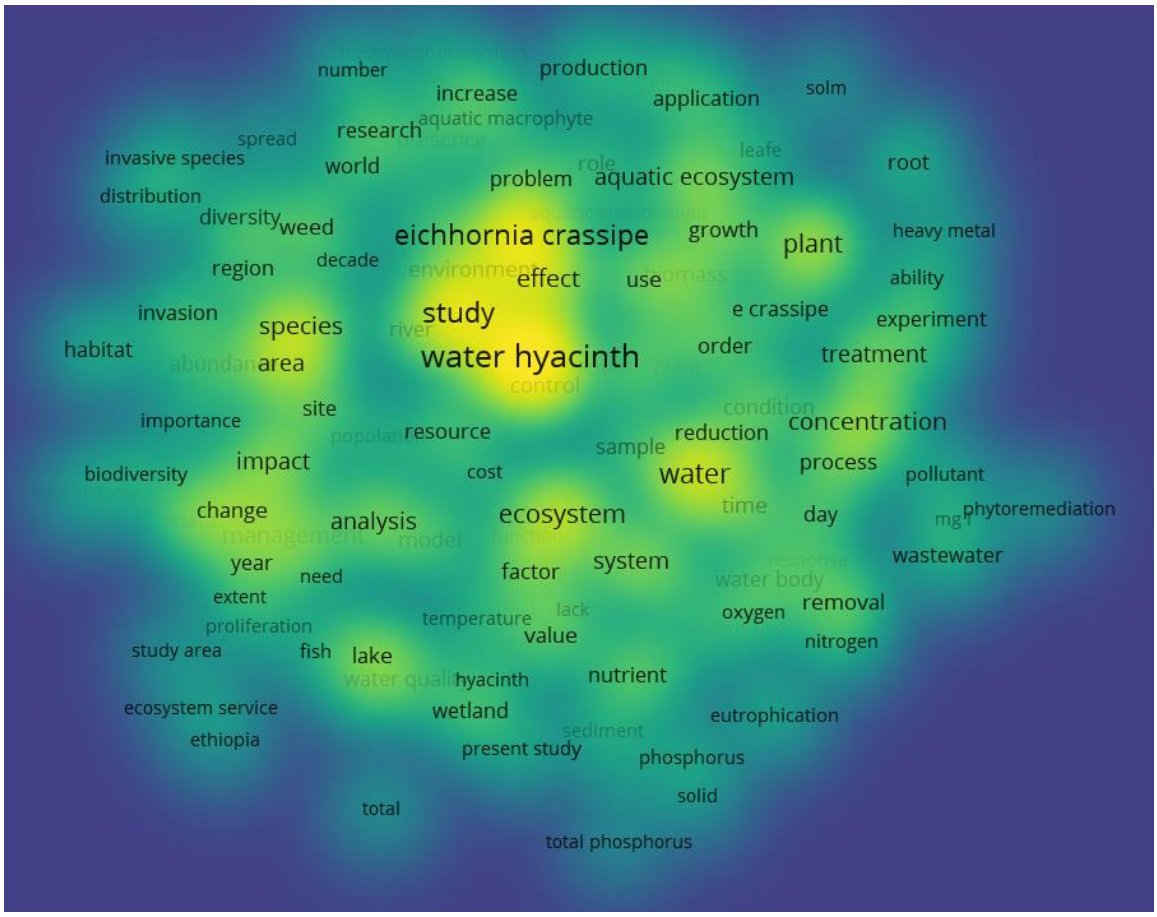


**Figure 8.** Density visualization based on co-word.

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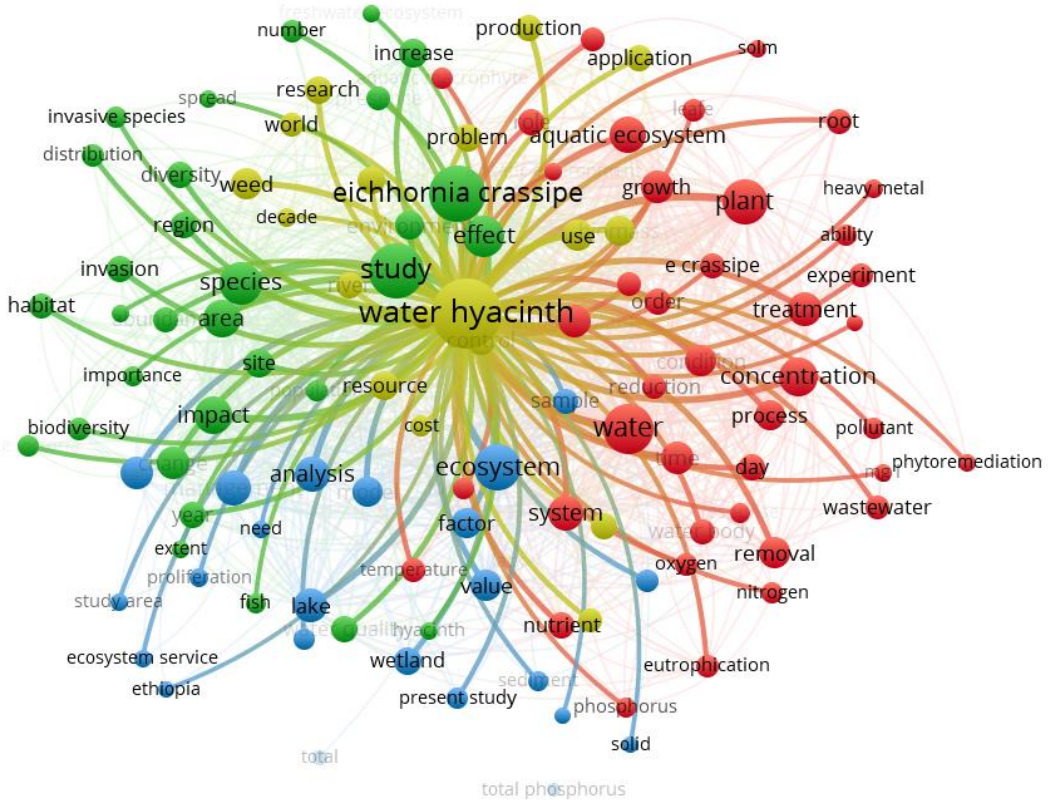


**Figure 9.** The cluster of water hyacinths.

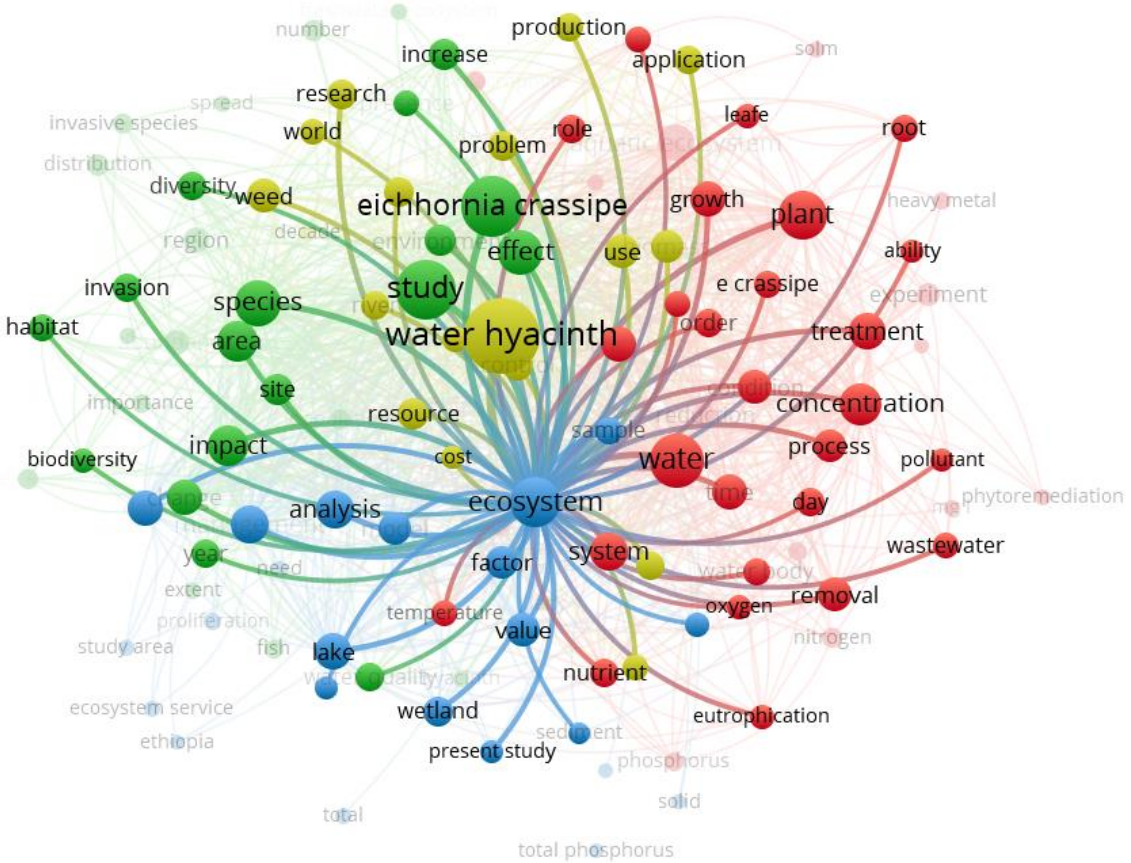


**Figure 10.** The cluster of ecosystems.

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## 4. CONCLUSION

This research successfully employed bibliometric analysis to illustrate research developments on water hyacinths and ecosystems. The database was obtained from Scopus using the keywords "water hyacinth" and "ecosystem" for 23 periods (2000-2023). The data search yielded 227 relevant articles. The results of the analysis of development data from this study are divided into three periods, namely the pioneering period (2000-2008), growth (2009-2015), and acceleration (2016-2023). The development of water hyacinth research was quite popular in 2016. From the results of the data visualization, four clusters were found. Most of the published research on water hyacinths and its ecosystem comes from the University of California. While the country that published the most articles came from India. Likewise, the authors who published the most articles came from Indian authors, namely Kanna, S. and Dube, T.

## 6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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