ASEAN Journal of Science and Engineering Education

Journal homepage: http://ejournal.upi.edu/index.php/AJSEE/

# Water Hyacinth and Education Research Trends from The Scopus Database: A Bibliometric Literature Review

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## ABSTRACT

This study aims to visualize data, trace the research trends, and evaluate research on water hyacinths and education from 2010 to 2023. This research used a database from Scopus. The data search used the keywords water hyacinth education and water hyacinth. We got 953 data articles and review articles. The data was then analyzed using Ms. Excel to analyze the number of articles, the number of citations per year, and the highest number of citations. The data was then mapped using the VOSviewer software. The mapping results were analyzed to see research trends based on related keywords. The results of the data visualization show that there are 374 keyword items grouped into 4 clusters. The results of taking data from 2010 to 2023 show that the research trend of water hyacinth and education tends to increase. Nonetheless, we evaluate that more research on water hyacinth is carried out in the fields of pure scientific research such as ecological communities, socio-economic effects, reproduction, its potential as bioenergy, and physiochemical properties. Thus, water hyacinth research opportunities in the field of education still have very broad potential to be carried out. This study was expected to provide information on research trends, mapping, and evaluation of research on water hyacinths and education.



## ARTICLE INFO

***Article History:***
*Submitted/Received 26 Apr 2023*
*First Revised 05 May 2023*
*Accepted 04 Jul 2023*
*First Available online 05 Jul 2023*
*Publication Date 01 Sep 2024*

***Keyword:***
*Bibliometric,*
*Education,*
*Mapping,*
*Trend,*
*Water hyacinth.*

## 1. INTRODUCTION

The water hyacinth (*Eichhornia crassipes*) is a free-floating aquatic plant that is native to South American origins and spread to other regions of the globe. Water hyacinth is known for its rapid growth and ability to reproduce quickly (Anandraj, 2018). It may pose significant problems, but it also has certain advantages, especially for aquatic environments. Environmental purification is one of water hyacinth's potential uses. The water hyacinth plant can purify water naturally. Water quality can be improved by its dense mat-like growth, which can absorb excess nutrients like nitrogen and phosphorus (Samal *et al.,* 2015).

Water hyacinth has the potential for biomass and energy production. The plant's rapid growth makes it a promising source of biomass for the creation of renewable energy (Bhattacharya & Kumar, 2010). Harvested water hyacinths can be used as animal feed or to make biofuels. Due to its capacity to absorb heavy metals and other contaminants, water hyacinth is also useful in phytoremediation initiatives, which aim to purify contaminated water bodies (Rezania *et al.,* 2015). In addition, the habitat and wildlife of water hyacinths can serve as a haven, a place for nesting, and a source of food for a variety of aquatic species, enhancing biodiversity in some habitats. However, water hyacinth can also be a problem (Forno, 2020).

There are other issues that water hyacinths can lead to, such as ecological disruption. Water hyacinth's quick growth can result in the production of dense mats that block sunlight, lowering oxygen levels and harming aquatic plants and animals (Pimentel, 2005). The floating mats produced by the water hyacinth plant can impede rivers, making them difficult to navigate, damaging irrigation systems, and sometimes even causing flooding (Lu *et al.,* 2007). In addition, water hyacinths have financial effects. Due to decreased water quality, clogged rivers, and damaged ecosystems, sectors like fisheries, agriculture, and tourism may experience financial losses in areas where water hyacinth is a serious problem (De Groote *et al.,* 2003). Water hyacinth was one of the most invasive aquatic plants in the world as a species. It is challenging to regulate and eradicate due to its capacity for fast reproduction and environmental adaptation (Joshi & Bhatt, 2020).

The potential and problems of the water hyacinth are objects of interest to researchers. Water hyacinth is researched from various fields such as environment, industry, economy, and even education. The water hyacinth can also serve as an educational resource. This plant gives students and researchers a chance to learn about the plant's many features and how they affect ecosystems. Students can learn about subjects including biology, ecology, environmental science, and sustainable resource management by adding water hyacinth into educational programs. Many studies have been conducted which provide valuable insights into the educational potential of water hyacinths.

García-Sánchez (2016) explored the use of water hyacinth as an educational tool in a secondary school. It examines the effectiveness of incorporating water hyacinth into environmental education activities and discusses the impact on students' knowledge and attitudes toward aquatic ecosystems. Chapman (2016) investigated the use of water hyacinths as an educational resource in primary schools in rural Tanzania. It highlights the plant's potential for teaching environmental science, biology, and other subjects and assesses its impact on students' understanding of ecological concepts. Van Efferen (2019) presented the water hyacinth as a model organism for inquiry-based learning in biology education. It discusses the plant's life cycle, growth patterns, and ecological interactions, providing educators with ideas for hands-on experiments and investigations using water hyacinths. There are many other studies regarding the educational potential of water hyacinths,

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

providing educators with ideas, methodologies, and case studies to integrate this aquatic plant into their teaching and learning activities. Even so, there are no articles that present bibliometrics and research trends regarding the education of water hyacinth in the last thirteen years. Therefore, this study aims to present a bibliometric review of research trends from water hyacinth and education research from the Scopus database. The objectives of this study include:

(i) Presenting a visualization of bibliometric data from water hyacinth and education research in the last thirteen years
(ii) Analyzing water hyacinth and education research trends in the last thirteen years
(iii) Evaluating water hyacinth and education research in the last thirteen years.

The database used in this study was taken from journal articles and review articles published in Scopus-indexed journals. This study uses VOSviewer and Ms.Excel software to map and analyze data. This study is expected to provide information on research trends, mapping, and evaluation of research on water hyacinths and education.

## 2. METHODS

The stages of this research are shown in **Figure 1**. This research was conducted by collecting data, processing data using Ms. Excel, mapping the data using the VOS viewer, and interpreting the mapping results.

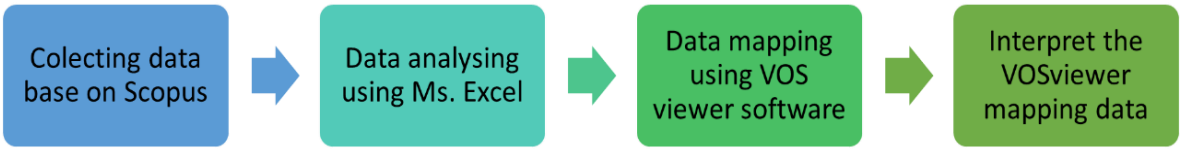


**Figure 1.** Research stages.

This study uses the Scopus database. Search data using the keywords "water hyacinth education" or "water hyacinth". The data obtained is filtered by year, namely from 2010-2023. The selected subject area consists of agricultural and biological sciences, environmental science, energy, materials science, biochemistry, genetics and molecular biology, medicine, veterinary, pharmacology, toxicology and pharmaceutics, decision sciences, economics, and econometrics and finance. The documents included in this study are only journal articles and review articles. The paper that was collected came from India, China, the United States, Brazil dan South Africa, Nigeria, Indonesia, Thailand, Malaysia, and others. From 3,981 papers we screened only 953 articles. The data obtained was saved in RIS and CSV formats.

Data stored in CSV format was analyzed using Microsoft Excel. Data were analyzed from the number of articles, the number of citations per year, and the highest number of citations. Data stored in RIS format was visualized using VOSviewer software. Before mapping, we chose terms related to water hyacinth and education.

The results of the data mapping were then interpreted to see research trends on "water hyacinth" and "education" over the last thirteen years. The results of the analysis were analyzed based on their relation to the terms that are often used in water hyacinth research.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

## 3. RESULTS AND DISCUSSION

### 3.1. Total Publications in the Last Thirteen Years

**Figure 2** shows the number of research on water hyacinths and education from 2010 to mid-2023. The trend of research on water hyacinths and education was increasing. A large increase began to occur in 2013, but after that, there was a decrease again, and was constant until 2018. From 2018 until now there has been an increase in the number of articles. From this data, it can be seen that the trend of research on water hyacinths and education tends to increase from year to year. Research on the potential and threats of water hyacinths is still an interesting object, especially the potential of water hyacinths to be used as a source of education. Research on water hyacinths in the field of education has not been widely carried out. Currently, water hyacinth is used more as an object of pure scientific research. Researchers have mostly conducted research on water hyacinth in terms of its potential as a phytoremediation agent, physiochemical properties, ecosystem dynamics, ecological communities, socio-economic effect, reproduction, and its potential as bioenergy (Basu *et al.*, 2021).

Water hyacinths can be used as a learning resource, especially for schools that are close to rivers, lakes, or waters there are water hyacinth grows there. Many lessons can be learned from this rapid growth plant. Water hyacinth can be used as a medium for studying the mechanism of floating aquatic plants, teaching the absorption of heavy metals by plants or known as phytoremediation. In addition, the strength of water hyacinth fiber makes it a material for crafts, and even crafts that are made can be sold. Besides that, there are still many studies that can be done using water hyacinth as a source or learning media.

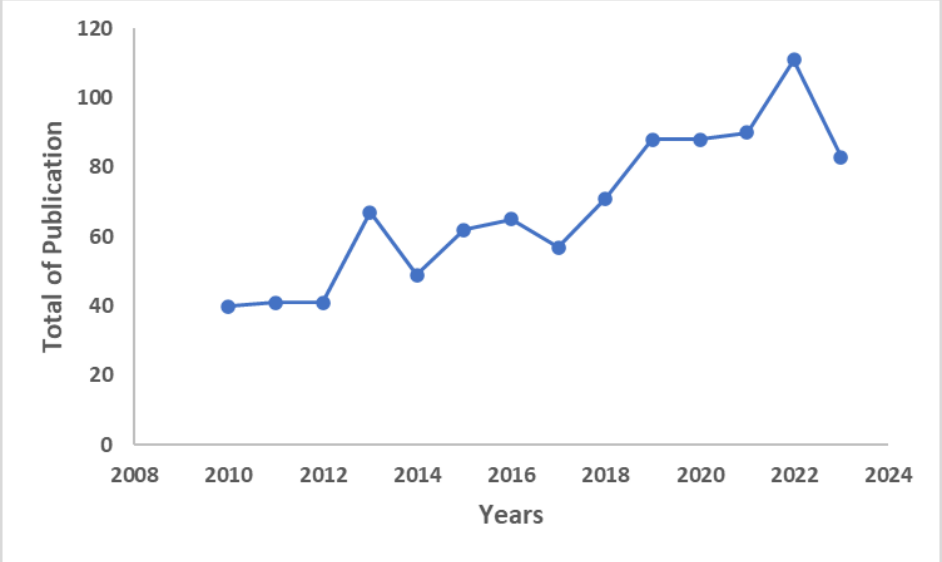


**Figure 2.** Number of water hyacinth studies in the last thirteen years

### 3.2. Number of Citations

**Table 1** shows the ten articles with the most citations from all the article data used in this study. The research with the most citations was an article entitled "Ecological and Socioeconomic Impacts of Water Hyacinth (*Eichhornia crassipes*): An Overview". This article examines the ecological and socio-economic impacts of growing water hyacinths. Ecological impacts include the impact of water hyacinth on air clarity, dissolved oxygen, phytoplankton productivity, decreased metal weight, impact on invertebrate air, the effect of water hyacinth on bird communities, and others. While the socio-economic impacts include water hyacinth

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

management which includes mechanical, chemical, and biological controls (Villamagna & Murphy, 2010). Other studies with the most sites discussed heavy metal phytoremediation, growth control, the potential of biomass content for bioenergy, as well as the content and nutrition of water hyacinth.

**Table 1.** Publications about water hyacinth with the most citations.

| Cites | Authors | Title | Year | Source | Reference |
|---|---|---|---|---|---|
| 399 | A.M. Villamagna | Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): A review | 2010 | Freshwater Biology | Villamagna and Murphy (2010) |
| 246 | X. Liu | Biomass-derived nitrogen self-doped porous carbon as effective metal-free catalysts for oxygen reduction reaction | 2015 | Nanoscale | Liu *et al.* (2015) |
| 245 | S. Malar | Lead heavy metal toxicity induced changes on growth and antioxidative enzymes level in water hyacinths [*Eichhornia crassipes* (Mart.)] | 2016 | Botanical Studies | Malar *et al.* (2016) |
| 147 | J. Singh | Assessment of bioavailability and leachability of heavy metals during rotary drum composting of green waste (Water hyacinth) | 2013 | Ecological Engineering | Singh and Kalamdhad (2013) |
| 123 | S. Rezania | The diverse applications of water hyacinth with main focus on sustainable energy and production for new era: An overview | 2015 | Renewable and Sustainable Energy Reviews | Rezania *et al.* (2015) |
| 123 | P. Saha | Phytoremediation of industrial mines wastewater using water hyacinth | 2017 | International Journal of Phytoremediation | Saha *et al.* (2017) |
| 118 | E. Syafri | Effect of sonication time on the thermal stability, moisture absorption, and biodegradation of water hyacinth (Eichhornia crassipes) nanocellulose-filled bengkuang (Pachyrhizus erosus) starch biocomposites | 2019 | Journal of Materials Research and Technology | Syafri *et al.* (2019) |
| 117 | J. A. Coetzee | A review of the biological control programmes on Eichhornia crassipes (C.Mart.) Solms (Pontederiaceae), salvinia molesta D.S.Mitch. (Salviniaceae), Pistia stratiotes L. (Araceae), Myriophyllum aquaticum (Vell.) Verdc. (Haloragaceae) and Azolla filiculoides Lam. (Azollaceae) in South Africa | 2011 | African Entomology | Coetzee *et al.* (2011) |
| 113 | H. Huang | Pyrolysis of water hyacinth biomass parts: Bioenergy, gas emissions, and by-products using TG-FTIR and Py-GC/MS analyses | 2020 | Energy Conversion and Management | Huang *et al.* (2020) |
| 101 | B. Lu | Removal of water nutrients by different aquatic plant species: An alternative way to remediate polluted rural rivers | 2018 | Ecological Engineering | Lu *et al.* (2018) |

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### 3.3. Mapping Results of Bibliometric Water Hyacinth Education Research

The mapping results with VOSviewer software show that there are four term clusters. The four clusters are shown in red, green, blue, and yellow. Each cluster describes the relationship between various topics. Cluster 1 (red) has a total of 177 items. The item are absence, abundance, agent, agriculture, algae, aquatic ecosystem, aquatic environment, aquatic macrophyte, aquatic weed, aspect, assessment, attention, average, benefit, biocontrol, biocontrol agent, biodiversity, biological control, biological control agent, Brazil, c aquaticum, case study, challenge, china, context, contrast, contribution, control, country, coverage, crassipe, damage, data, density, development, distribution, dry season, eccritotarsus cartaniensis, ecosystem, efficacy, egg, echhornia, environmental condition, Ethiopia, eutrophic water, eutrophication, example, field, first time, fish, fishing, generation, habitat, herbicide, herbivory, identification, impact, implication, importance, interaction, invasion, invasive aquatic plant, invasive aquatic weed, invasive plant, invasive species, invasive water hyacinth, invasive weed, irrigation, knowledge, lack, lake, lake Victoria, large amount, literature, location, loss, management, Mexico, eichhorniae, negative effect, negative impact, number, nutrient concentration, observation, open water, part, period, petiole, place, plant biomass, plant species, Pontederia crassipe, population, prediction, presence, proliferation, region, relation, release, reproduction, resource, response, review, risk, river, role, selection, significant difference, site, size, south Africa, south America, species, spread, stage, strategy, success, suitability, survey, tolerance, total, USA, variable, variation, vegetation, water hyacinth echhornia crassipe, water hyacinth infestation, water hyacinth invasion, water hyacinth plant, water quality, water surface, weed, wetland, and world.

Cluster 2 (green) have a total of 177 items. The item are abstract, acid, adsorbent, adsorption, adsorption capacity, adsorption process, advantage, amount, analysis, aqueous solution, bio oil, biochar, bioethanol, biofuel, biogas, biogas production, biosorption, blend, capacity, carbon, catalyst, cellulose, CH4, characterization, chemical, CO2, composite, composition, conversion, cost, current study, degradation, demand, dye, efficiency, Eichhornia crassipes, electron microscopy, emission, energy, enzyme, ethanol, experimental data, extraction, feasibility, feedstock, fermentation, fiber, FTIR, group, hemicellulose, hyacinth, improvement, industry, initial dye concentration, ion, lignin, low cost, maximum, maximum adsorption capacity, mechanism, methane, min, morphology, NaOH, nature, optimization, paper, performance, phase, phenol, potential, present work, pretreatment, process, product, production, property, pyrolysis, raw material, regard, SEM, sewage, solution, spectroscopy, step, structure, substrat, sugar, synthesis, technique, temperature, ton, utilization, volume, waste, water hyacinth biomass, water hyacinth fiber, work, XRD, and yield.

Cluster 3 (blue) has a total of 74 items. The item is absorption, accumulation, April, aquatic plant, arsenic, bioaccumulation, bioavailability, biochemical oxygen demand, biological oxygen demand, BOD, cadmium, chemical oxygen demand, chlorophyll, chlorophyll content, chromium, COD, concentration contaminant, copper, correlation, day, determination, e crassipe, effluence, Egypt, heavy metal, high concentration, high level, higher concentration, highest value, hour, human health, Indonesia, initial concentration, iron, lead, metal, metal concentration, nitrate, oxygen, parameter, pH value, photosynthesis, phytoremediation, plant tissue, pollutant, polluted water, pollution, pond, potential use, ppm, the present study, relative growth rate, remediation, removal, removal efficiency, root, sediment, shoot, stem, technology, total phosphorus, toxicity, trend, turbidity, uptake, wastewater, wastewater treatment, water hyacinth root, water lettuce, water pollution, water sample, week, zink.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
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Cluster 4 (yellow) has a total of 62 items. The item is Alternative, animal, application, availability, bacterium, basis, bioremediation, combination, compost, composting, composting process, content, crop, crude protein, cultivation, decomposition, difference, dry weight, echornia crassipe, electrical conductivity, extract, feed, fertilizer, field experiment, flower, food, growth performance, growth rate, India, leaf, microorganism, moisture content, nitrogen, organic carbon, organic matter, organic waste, percentage, phosphate, phosphorus, plant growth, potassium, present investigation, productivity, proportion, protein, quality, ratio, respect, seed, a significant increase, significant reduction, source, total nitrogen, treatment, variety, vermicompost, vermicomposting, water hyacinth composting, water hyacinth leafe, weight, and weight gain.

**Figure 3** shows a network visualization of each keyword. Keywords on the map are represented by colored circles. Different colors of the circles indicate different clusters (Al Husaeni & Nandiyanto, 2022; Al Husaeni *et al.,* 2023). The size of the circle and the size of the letters in the keywords are directly proportional to the frequency of occurrence of the keywords in the abstract and the title of the article (Al Husaeni & Al Husaeni, 2022; Maryanti *et al*., 2023). The circle size and font size increased when the keyword was used more in the article (Donthu *et al.,* 2021). **Figure 3** also shows the relationship between each keyword and each cluster. The relationship is depicted by a curved line connecting the two circles. The thickness of the line indicates the greater relationship between the two keywords (Brown *et al.,* 2020). From **Figure 3** it can also be seen that the two biggest keywords are in different clusters. "Hyacinth" is in cluster 2 which is marked in green with a total of 373 links, 803 occurrences, and 12551 total link strength. The keyword "Crassipes" which is part of the Latin name water hyacinth (*Eichhornia crassipes*) is in cluster 1 which is marked in red with a total of 373 links, 448 occurrences, and 7320 total link strength.

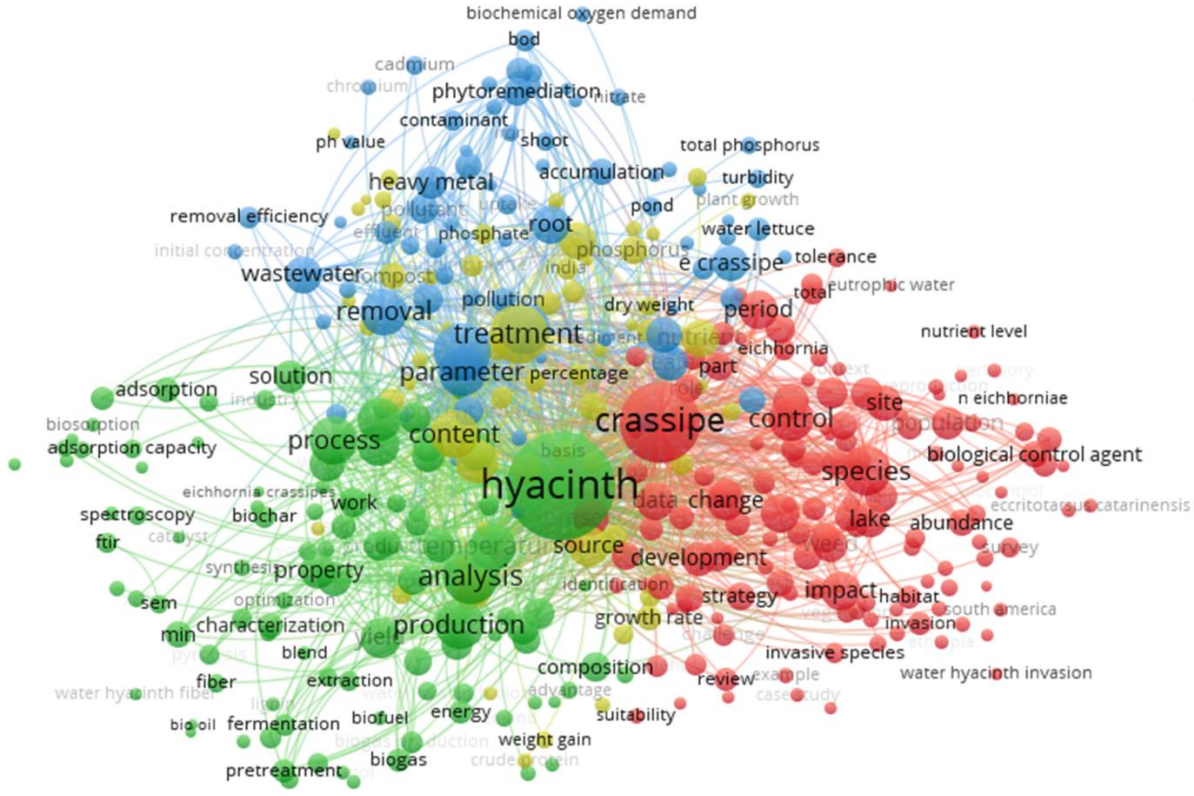


**Figure 3.** Network visualization of the water hyacinth and education.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

From the network visualization, it is known that research on water hyacinth and water hyacinth and education is related to many terms. The total links obtained in this study are 38,008 the total link strength is 135,314. The terms most related to water hyacinth and water hyacinth and education are shown in **Figure 4**. The ten most related terms include phytoremediation, heavy metal, source, application, removal, species, concentration, treatment, crassipe, and hyacinth. From this data, it is found that most of the research on water hyacinth has recently been carried out in the environmental field. While very less research in the field of education.

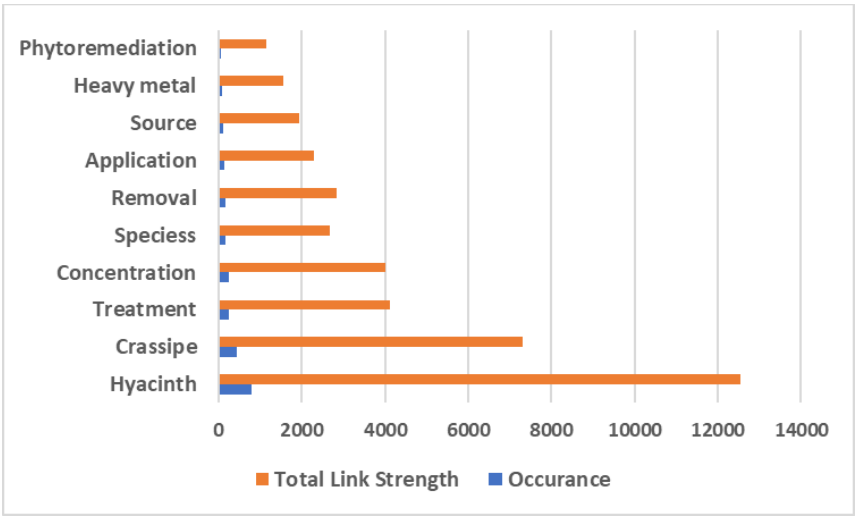


**Figure 4.** The most related term to the water hyacinth and education.

**Figure 5** shows an overlay visualization. This visualization overlay can make it easier to show the frequency of keywords in a certain year range (Nandiyanto *et al.*, 2023). From **Figure 5**, it can be seen that the keywords that often appear in the latest research are mostly in cluster 2.

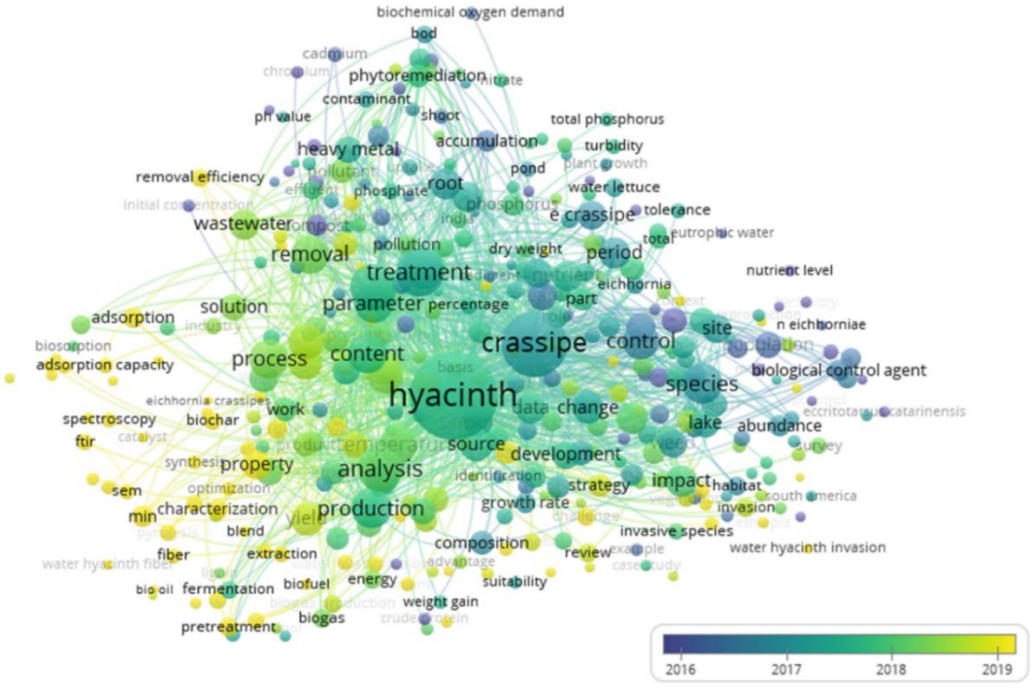


**Figure 5.** Overlay visualization of the water hyacinth and education.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
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**Figure 6** shows the visualization analysis of the density of "water hyacinth" and "education" research. The density map shows the larger the diameter of the circle, and the brighter the color depicts the denser and more often the keyword occurs (Hamidah *et al.,* 2020; Nandiyanto *et al.,* 2021).

From the mapping results it can be seen that the keyword "water hyacinth" is still often used in various studies. However, the keyword water hyacinth and education is still rarely used and there is very little research on the use of water hyacinth in educational research. Thus, water hyacinth research opportunities in the field of education still have very broad potential to be carried out. the potential and threats that water hyacinth has can be used as a source of contextual learning about the environment, plants, ecosystem interactions, and biology, especially for schools adjacent to waters that are invaded by water hyacinth.

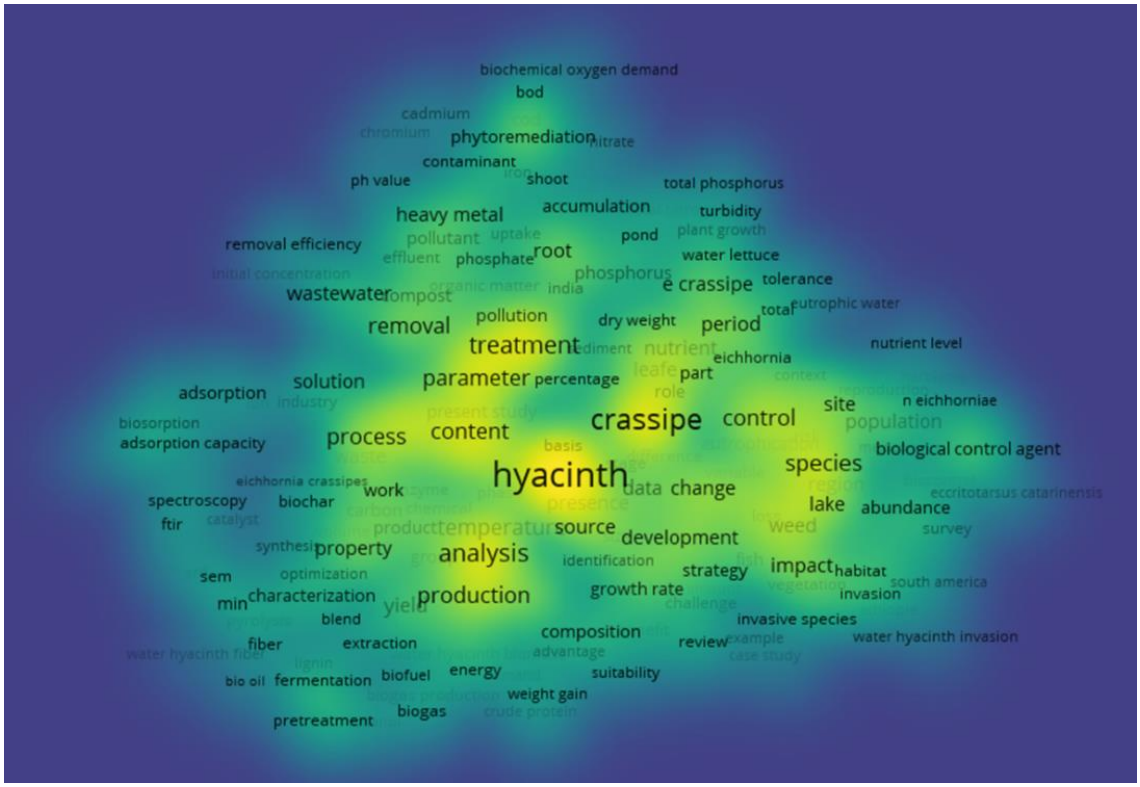


**Figure 6.** Density visualization of water hyacinth and education.

## 4. CONCLUSION

This investigation intends to examine research on water hyacinth and education from 2010 to 2023, trace research patterns, and visualize data. 953 articles and reviews from the Scopus database were used in this study. The data visualization's findings indicate that there are 374 keyword items divided into 4 clusters. The analysis of data from 2010 to the middle of 2023 shows that the research trend of water hyacinth and education tends to increase. However, we evaluate that more work done on the water hyacinth in the areas of pure science, such as ecological communities, socioeconomic implications, reproduction, its potential as a source of bioenergy, and physicochemical qualities. while research on water hyacinths in the field of education is still lacking. As a result, there is still a lot of room for water hyacinth research in the field of education. This study was expected to provide information on research trends, mapping, and evaluation of research on water hyacinths and education.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

## 5. 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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