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Review Paper

Antimicrobial Natural Dyes for Fabrics: A Bibliometric Analysis

Kanak Saxena
Chemistry Department, Manoj Pandey Block, National Defence Academy, Pune, Maharashtra-411023, India
saxenakanak04@gmail.com

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Abstract

The necessity of leading a healthy and hygienic lifestyle is evidently increasing. Among the unseen threats to health, one of them is the presence of microbes in our surroundings. To address this challenge and safeguard against these microbes, numerous methods have emerged. One such method involves the use of antimicrobial natural dyes for fabrics. This approach proves highly effective since fabrics are commonly dyed, offering a simple yet efficient means of protection against microbes without requiring additional efforts. Due to the increasing presence of microorganisms in the atmosphere, antimicrobial properties, along with other desirable attributes, have become essential requirements. The present review article is actively exploring dye derivatives endowed with inherent antimicrobial properties to meet this demand. This paper provides a thorough bibliometric analysis, incorporating visualization mapping through VOS viewer software, which examines research in this field up to 2023.A meticulous selection process resulted in the inclusion of 248 articles, adhering to specific selection criteria. The analysis delves into trends in paper publications across various journals and countries, while also exploring citation and co-citation patterns among authors and countries.

Keywords: Antimicrobial Natural Dyes, Fabrics, Bibliometric analysis, VOS viewer.

Introduction

With the advancement of life style, requirements to face the new challenges generating by it are continuously increasing. One of such challenge is in the form of different type of pollutions[1,2] in the environment which are gradually increasing due to various human activities e.g. construction, release of harmful gases, improper waste management, etc. Water pollution, air pollution and soil pollution are majorly discussed categories while another type of contamination that is actually present in all segments is microbial contamination[3] which includes bacteria, virus and fungus.

Population of various microbial strains is continuously increasing along with the entry of new types of strains thus posing threat to human being and other animals. Following the COVID-19 pandemic, microbial pollution has garnered significant attention and become a widely discussed topic[4]. It has been observed that microbial pollution is now focus of researcher and regular efforts are being made to reduce such threats[5]. Another aspect of research on these microbes involves safeguarding humans from them and thereby preventing related diseases.

Encountering such microbes in not only restricted to place like hospital or contaminated areas prone to microbes but due to unavoidable circumstance each and every one is subjected to come across the microbes present in the environment on daily basis. Now such microbes are freely present in the environment and can travel from contaminated area to other area, may grow in the given condition. Several human activities also responsible in providing the suitable conditions for such microbes like sweating, dust on clothes, damping, etc.

Antimicrobial agents are utilized to destroy or inhibit the growth of microorganisms. These substances play a crucial role in preventing or treating infections and include a range of categories such as antiseptics, antibiotics, antivirals, antifungals, antiparasitic, as well as disinfectants[6]. Continuous efforts are being made to avoid interaction to such microbes. In this regards, number of fighting mechanisms have been developed for example antimicrobial finishes, sprays, sanitizers, antimicrobial washing techniques. One such remediation that is capturing considerable attention among researchers is the integration of antimicrobial properties into clothing. In the current era, antimicrobial textiles prove to be highly beneficial in settings such as hospitals and environments where harmful microbes are prevalent[7].

Textiles are everywhere and hold a crucial role in human society[8]. Applying naturally occurring antimicrobial substances to textiles or fabrics is a method used to address antimicrobial challenges. Coloured fabrics are used in daily life and can act as antimicrobial finishes. Bioactive textiles gained significant attention during the COVID-19 pandemic due to their antimicrobial properties[9].

Antimicrobial textiles can be classified according to their effectiveness against specific types of microbes, such as antibacterial, antifungal, and/or antiviral[10–14].

Some antimicrobial textiles may even exhibit the ability to combat bacteria, fungi, and viruses all at once[13,15]. For example, peanut red skin extracts were used against Gram + ve bacteria, Gram − ve bacteria, and pathogenic fungus whereas bioactive substances extracted from Streptomyces have been found active against bacteria like Staphylococcus epidermidis and Staphylococcus aureus.

Coloration is a pivotal stage within the textile value chain, where textile products undergo dyeing or printing processes to enhance their fashion appeal. This textile coloration procedure comprises distinct phases, encompassing pre-treatment, the actual dyeing or printing, and final finishing steps. Colour is imparted into the clothes using different type of dyes ranging from natural to synthetic. Synthetic textile dyes, traditionally used in the industry, are known for their hazardous and toxic nature, lacking any biological activity[16].

In contrast, natural dyestuffs offer an innovative and sustainable alternative to chemicals in the textile industry, particularly noteworthy for their antimicrobial properties[17].

Microorganisms present a promising source of colorants with significant economic potential.

Due to their superior biodegradability and enhanced eco-compatibility, microbial pigments offer potential for future development and can serve as intelligent substitutes for artificial pigments[18,19].

During dye finishes either mordant[20], dye itself or finishing material play role as antimicrobial entity. The present work focuses on the work where natural dye itself having such groups which act as antimicrobial[21–23].

Natural dyes, acting as antimicrobial agents, serve a dual role by combating microbes while also being environmentally friendly due to their natural origin, thus posing no harm to the environment.

Methodology

Several steps were taken to select data for the current analysis. Initially, the topic was chosen based on the requirements of the current research area and anticipated future attention. Following this, keywords relevant to the topic were identified to gather articles. The Dimension software was utilized as the database search engine due to its free accessibility. The search was conducted on February 10, 2024, using keywords such as Antimicrobial, Dye, Textile, and Fabric. Further filters were applied to refine the search, focusing on keywords present in the title and abstract and limited to articles only. A total of 515 articles were identified under these search criteria. Subsequently, a detailed analysis was conducted, and only those articles that were relevant and met the requirements of the topic under consideration were selected, excluding review articles. Ultimately, 248 original research articles were chosen for the bibliometric analysis. VOS viewer is a specialized software tool designed for creating and visualizing bibliometric networks in graphical formats[24]. In the present study, this software is utilized to generate visual representations encompassing various aspects such as source connections, author networks, affiliations by country, citation networks, publication trends, and journal classifications.

Results and Discussion

Publication trend of articles: An analysis conducted year by year for all articles has yielded the data presented in Table-1. The year-wise publication trend indicates that research activity commenced in 2004 and remained at a relatively low pace until 2009. However, starting from 2010, a consistent growth trajectory in the research field is evident from the data. This growth corresponds with increased efforts to address microbial contamination and mitigate associated issues. The pandemic likely influenced the slight decrease in research activity observed in 2020. The peak year for article publications was 2022, which can be attributed to the outbreak of Covid-19 in 2020.

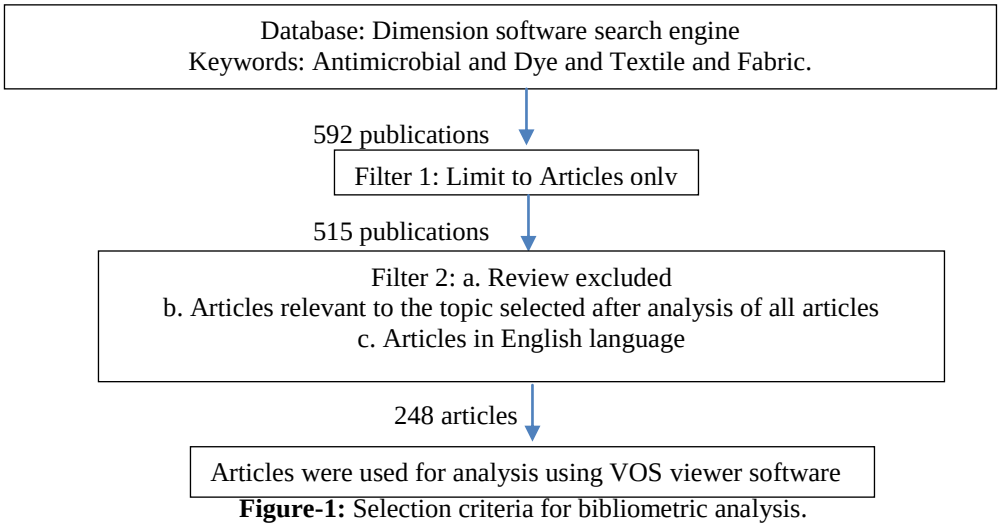

Figure-1: Selection criteria for bibliometric analysis.

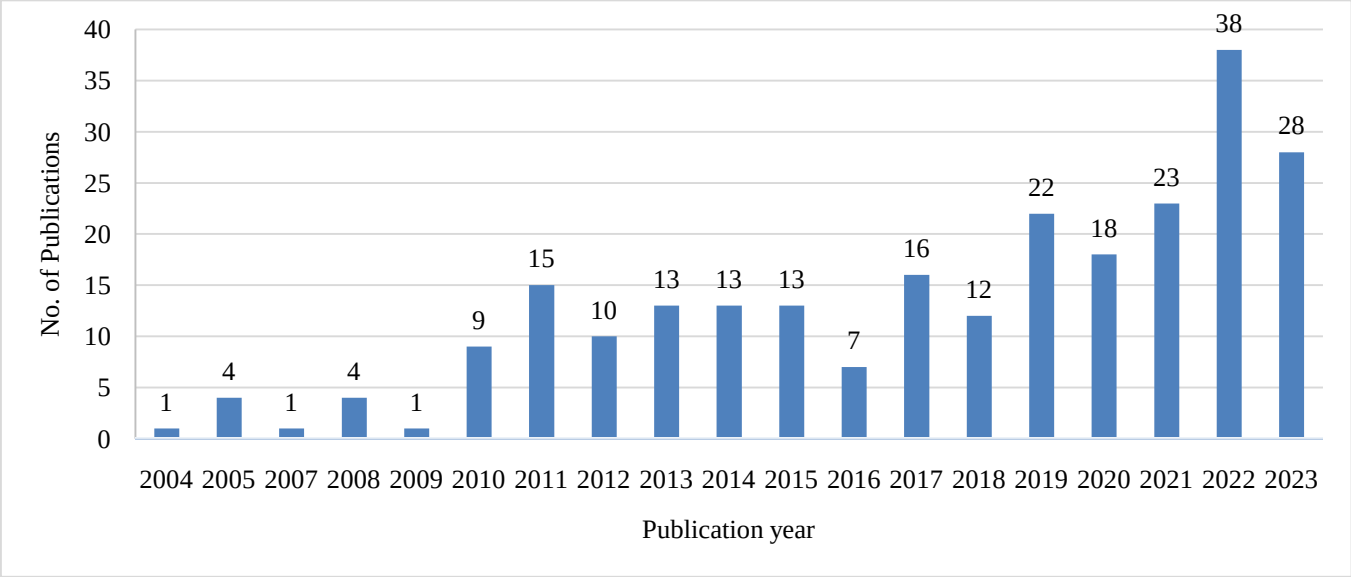

Figure-2: Publication Trend of articles year wise.

Table-1: Publication trend analysis in group.

Groups	Total Publications	% TP
Gr 1(2004-2008)	10	4.0
Gr 2(2009-2013)	48	19.4
Gr 3(2014-2018)	61	24.7
Gr 4(2019-2023)	129	51.4

The analysis of groups of years reveals a significant increase in publication rates. Upon examining the next group of years, it is noted that the publication trend indicates more than double the number of publications in group 4 compared to group 3.

Publication trend and citation analysis among journals: All selected articles 248 were published in 125 different journals. Table-2 shows the data of 10 leading journals which published five or more than five articles. Fibre and polymers journal published the most article in the relevant field counting 24. These top 10 journals are responsible of publication of 38% of total published articles.

The citation analysis reveals that the maximum citations originated from articles published in the journal Dyes and Pigments, which had only 7 publications. Conversely, the journal Fibres and Polymers, which had the highest number of published articles, ranked fifth in terms of total citation count, with 143 citations. This underscores the impact of individual articles on overall journal influence. Notably, there are two journals, Carbohydrate Polymers and Coloration Technology, with more than 100 citations, attributed to only 2 published articles each. Further examination showed that Coloration Technology accumulated a total citation count of 124, with one article published in 2023 and another in 2004. The 2004 article, assumed to be one of the seminal works in the selected topic, explored the impact of natural dyes on gram-negative bacteria. Intriguingly, all citations were attributed to this single article from 2004.

Table-2: List of Top 10 journals.

Journal Name	No. of Articles	Citations
Fibers and polymers	24	143
Pigment & resin technology	13	125
Textile coloration and finishing	10	43
Journal of natural fibers	9	73
Dyes and pigments	7	713
Molecules	7	122
Textile research journal	7	81
Cellulose	6	207
Journal of cleaner production	6	511
Journal of the korean society of clothing and textiles	5	24

Figure-3 illustrates the connection between various journals and the journals where articles were cited. The size of each circle corresponds to the number of articles, while the thickness of the connecting lines indicates the frequency of citations from the articles in one journal to another.

Citation and Co-citation of titles: Among the 248 selected documents, 194 titles were cited by other documents in various journals. Of these, 51 titles were cited more than 20 times, and 13 titles were cited more than 50 times. Notably, 7 titles received over 100 citations each.

Table-4 presents the list of titles cited more than 100 times. The title published in 2005 accumulated the maximum citations, serving as an initiating point for research on the topic, which has since gained momentum.

Table-3: List of journals based on citations.

Journal Name	No. of Articles	Citations
Dyes and Pigments	7	713
Journal of cleaner production	6	511
Cellulose	6	207
Carbohydrate Polymers	2	154
Fibers and Polymers	24	143
Pigment & Resin Technology	13	125
Coloration Technology	2	124
Molecules	7	122

Table-4: List of Titles with citations.

Title	Citations	Ref.
Antimicrobial activity of wool fabric treated with curcumin	270	22
Antimicrobial activity of some natural dyes	261	23
Assessment of colorimetric, antibacterial and antifungal properties of woollen yarn dyed with the extract of the leaves of henna (Lawsonia Inermis)	173	25
Antimicrobial properties of natural dyes against Gram negative bacteria	124	21
Assessment of antibacterial activity of wool fabrics dyed with natural dyes	105	26
Assessment of antimicrobial activity of Catechu and its dyed substrate	105	27
A new approach for natural dyeing and functional finishing of cotton cellulose	105	28

The co-citation analysis reveals that 40 articles were cited together 20 times, while 24 articles were co-cited 30 times. Furthermore, 13 articles were co-cited with other articles more than 50 times. Figure-4 visually represents the co-citation of sources, with the size of each circle indicating the frequency of co-citation, and the branching links illustrating the articles cited together.

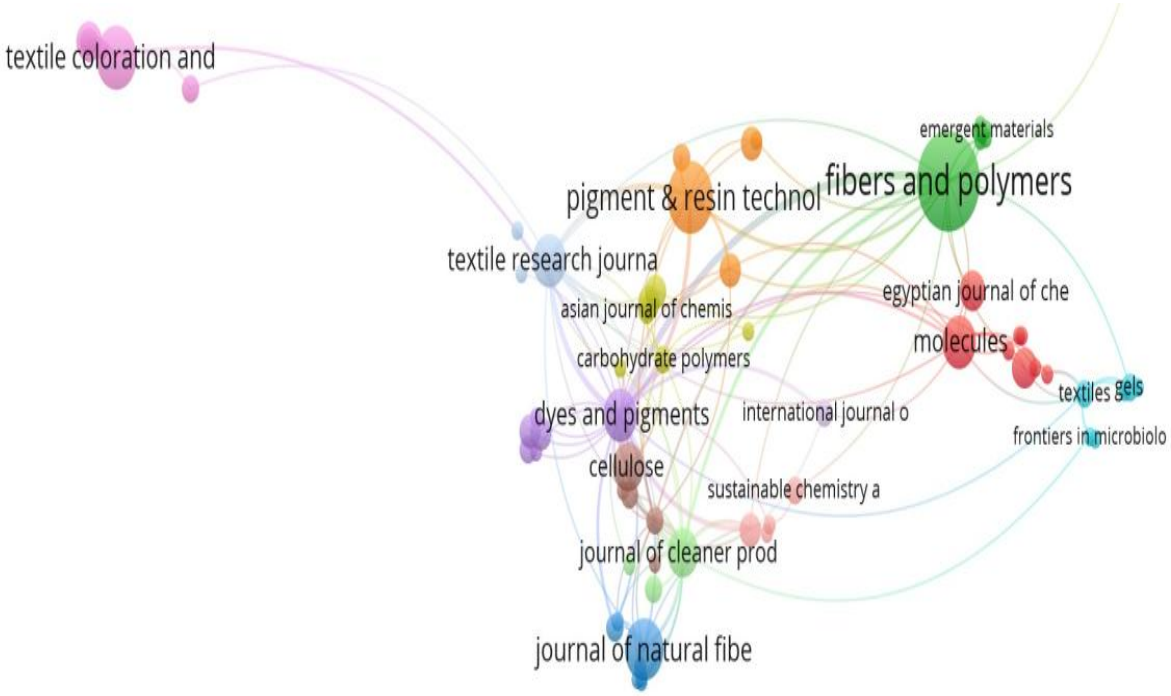

Figure-3: Network visualization map of most connected sources.

Authors' Citation, Co-authorship and co-citation analysis: In total, 851 authors are associated with the published articles. Among them, 658 authors received citations for their articles. Additionally, 88 authors contributed to two articles each, while 6 authors were associated with four articles each among the selected articles and received citations more than 25 times. Furthermore, 18 articles were written by sole authors, while all other articles were co-authored.

The co-citation analysis provides insights into how frequently authors are cited together, suggesting a level of association or similarity in their research. As author Deepti Gupta got maximum citation count and associated with 2 articles. Gang Sun is one of the author who is associated with 4 papers ant got total citation count of 142. Manzoor Nikhat, Faqeer Mohammad and Mohammad Shahid are co-authored 3 articles and received citations count 301. Figure-5 shows the web of most cited authors.

Table-5: List of top authors and their citation count.

Authors	Documents	Citations
Deepti Gupta	2	385
Nikhat Manzoor, Faqeer Mohammad, Mohammad Shahid	3	301
Aijaz Ahmad, Mohd Ibrahim khan, Shafat Ahmad Khan, Mohd Yusuf	2	278
Gang Sun	4	142
Daryoush Abedi, Sayed Majid Mortazavi	2	131

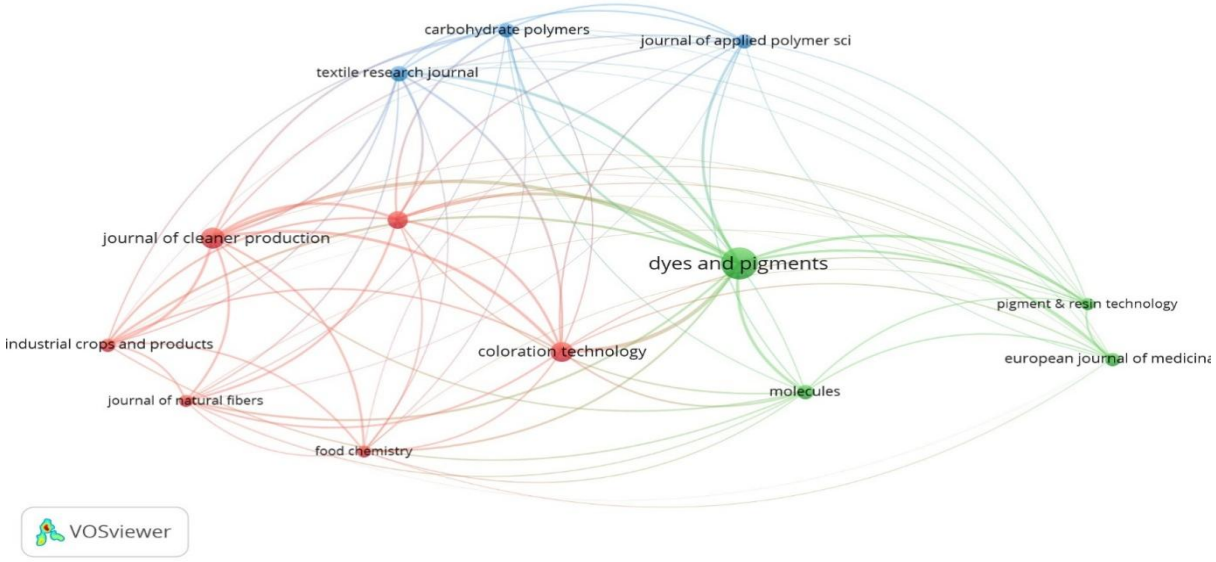

Figure-4: Co-citation among sources.

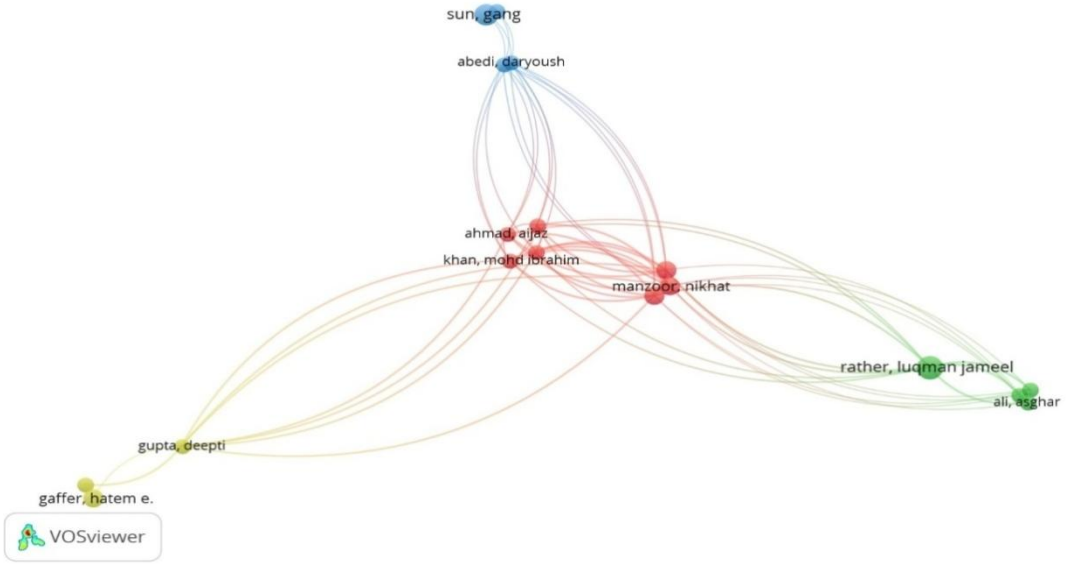

Figure-5: Citation web of most cited authors.

Publication trend, citation analysis and bibliographic coupling among countries: A total of 40 countries have contributed to the relevant research area, with the top 5 countries listed in Table-6. An analysis reveals that India leads in paper publications with a total of 43, followed closely by Egypt with 42 publications. China, Saudi Arabia, and Iran occupy the third, fourth, and fifth positions with 23, 23, and 13 articles respectively. India's prominence in this chart can be attributed to its population size, which correlates with a higher concentration of microbes in the environment and consequently, a greater focus on mitigating this issue.

Table-6: List of top five countries (based on no. of documents).

Country	Documents	Citations
India	43	1223
Egypt	42	563
China	23	445
Saudi arabia	23	182
Iran	13	221

Another approach was taken in Table-7, listing the top countries based on citation count. Once again, India and Egypt lead the chart with the highest citations, 1223 and 563 respectively. Notably, the United States ranks third with 544 citations, despite having only 12 articles, highlighting the significance of their work in this field.

Table-7: List of top five countries (based on citation count).

Country	Documents	Citations
India	43	1223
Egypt	42	563
United states	12	544
China	23	445
Iran	13	221

Bibliographic coupling among countries indicates the citation of articles from one country by other countries. This reveals trends in the focus and exploration of similar topics by different countries. The size of each country node represents the number of citations from that country, while the color transition indicates the citation of articles associated with different years.

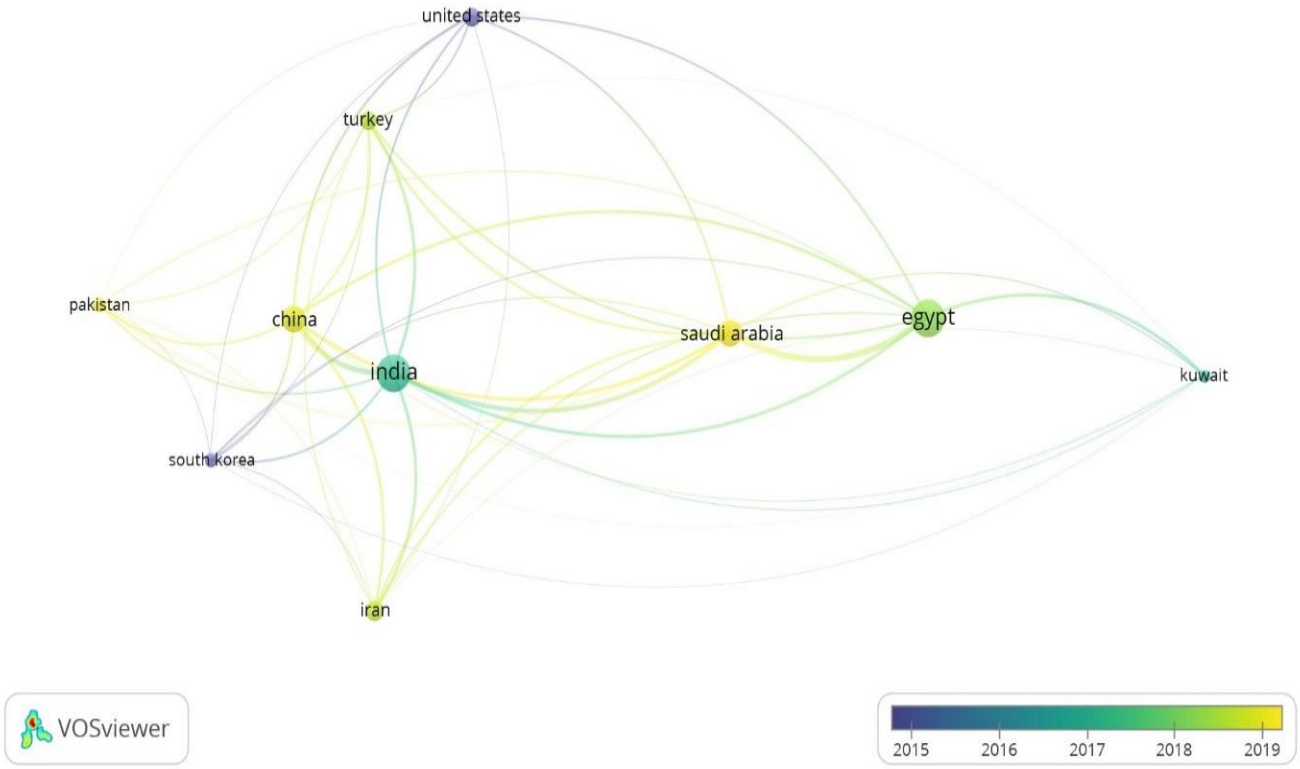

Figure-6: Overlay visualisation of Bibliographic coupling among countries.

Conclusion

A total of 248 articles were selected for analysis, covering the period from the first relevant publication in 2004 to 2023. These articles underwent comprehensive examination across multiple dimensions, encompassing publication trends across different years, journals, and countries, as well as citation and co-citation analyses among authors and journals. The primary aim of this bibliometric study was to assess the significance of antimicrobial dyes for fabrics in addressing the challenges posed by microbial attacks in the environment. This was achieved through the utilization of VOS viewer application's mapping capabilities to highlight pertinent trends.

The systematic analysis conducted in this study highlights the pivotal role of antimicrobial dyes for fabrics as a defense against microbes in various environments. This is evidenced by the significant number of published articles and the citations received by these articles. It is clear that this area of research has garnered considerable interest in recent years, with over 50% of the publications falling within the 2019-2023 timeframe, likely influenced by the challenges posed by COVID-19. The highly cited articles in this field, particularly those from the early years (2004 and 2005), underscore the foundational importance of natural components and dyes. This emphasizes the enduring impact of these pioneering research articles on the field of antimicrobial activity of natural dyes.

In conclusion, this bibliometric analysis provides valuable insights into the current landscape of research on the antimicrobial activity of natural dyes. It emphasizes the need for further investigations to bridge gaps in understanding the diverse applications of natural dyes against microbes. This includes assessing the effectiveness of existing natural dyes against different strains of microbes, exploring the development of new types of natural dyes, and evaluating their efficacy in combating various microbial strains. Furthermore, fostering collaboration among researchers from different countries is crucial for a comprehensive exploration of the potential applications of natural dyes in this field. Such international cooperation can facilitate the exchange of knowledge and ideas, thereby advancing understanding and capabilities in addressing the critical issue of microbial strains.

References

1. Bhardwaj, L. K.; Singh, V. V.; Dwivedi, K.; Rai, S. (2023). A Comprehensive Review on Sources, Types, Impact and Challenges of Air Pollution. *Preprints 2023*, 2023111245. https://doi.org/10.20944/preprints202311.1245.v1

2. Chen, B., & Kan, H. (2008). Air pollution and population health: a global challenge. *Environmental health and preventive medicine*, 13, 94-101.

3. Microbiological Pollution—An overview. Science Direct Topics. (n.d.). Retrieved March 6, 2024.

4. Moelling, K., & Broecker, F. (2020). Air microbiome and pollution: composition and potential effects on human health, including SARS coronavirus infection. *Journal of environmental and public health*, *2020*(1), 1646943.

5. Breijyeh, Z., & Karaman, R. (2023). Design and synthesis of novel antimicrobial agents. *Antibiotics*, 12(3), 628.

6. Di Martino, P. (2022). Antimicrobial agents and microbial ecology. *AIMS microbiology*, 8(1), 1.

7. Antimicrobial Textile—An overview. *Science Direct Topics*. (n.d.). Retrieved March 6, 2024.

8. Sanders, D., Grunden, A., & Dunn, R. R. (2021). A review of clothing microbiology: the history of clothing and the role of microbes in textiles. *Biology letters*, 17(1), 20200700.

9. Nosheen, A., Ashraf, M., Hussain, M. T., Aziz, H., Tahir, M. F., & Akram, S. (2023). Development of functional cotton fabric by simultaneous dyeing and finishing with a novel bioactive reactive dye. *New Journal of Chemistry*, 47(4), 1872-1886.

10. Chitichotpanya, P., Vuthiganond, N., Inprasit, T., & Chutasen, P. (2024). Bioactive and Multifunctional Wool Textiles Finishing with Diospyros mollis Griff. Extract. *Journal of Current Science and Technology*, 14(1).

11. Sabyrkhanova, S., Ork Efendioglu, N., Yeldiyar, G., & Bitlisli, B. O. (2024). Investigation of dyeing, antibacterial and antifungal properties of blended fabrics treated with plant-based dyestuffs and mordants as shoe materials. *Coloration Technology*, 140(4), 598-611.

12. Pallath, N., Johnson, S., Paul, E., & TA, R. (2024). Prodigiosin pigment from Serratia marcescens MBM-17 from facial acne as antimicrobial agent. *Environmental Quality Management*, 33(4), 275-283.

13. Rehan, M., El-Hawary, N. S., Mashaly, H., El-Shemy, N. S., & El-Sayed, H. (2023). Concurrent dyeing and finishing of textile fabrics using chemically modified Peanut Red skin extract. *Fibers and Polymers*, 24(7), 2357-2365.

14. Nuanjohn, T., Suphrom, N., Nakaew, N., Pathom-Aree, W., Pensupa, N., Siangsuepchart, A., ... & Jumpathong, J. (2023). Actinomycins from Soil-Inhabiting Streptomyces as Sources of Antibacterial Pigments for Silk Dyeing. *Molecules*, 28(16), 5949.

15. Qi-Yue, Y., Ting, Z., Ya-Nan, H., Sheng-Jie, H., Xuan, D., Li, H., & Chun-Guang, X. (2020). From natural dye to herbal medicine: A systematic review of chemical constituents, pharmacological effects and clinical applications of indigo naturalis. *Chinese Medicine*, 15(1), 127.

16. Costa, E. M., Silva, S., Tavaria, F. K., & Pintado, M. (2022). Insights into the Biocompatibility and Biological Potential of a Chitosan Nanoencapsulated Textile Dye.

International Journal of Molecular Sciences, 23(22), 14234.

17. Cuce, M. (2022). Investigation of Color, Fastness, and Antimicrobial Properties of Wool Fabrics Dyed with Rosa Canina Leaf Extract. *Journal of Natural Fibers*, 19(3), 823–834.

18. Sengupta, S., & Bhowal, J. (2023). Characterization of a blue-green pigment extracted from Pseudomonas aeruginosa and its application in textile and paper dyeing. *Environmental Science and Pollution Research International*, 30(11), 30343–30357.

19. Mouro, C., Gomes, A. P., Costa, R. V., Moghtader, F., & Gouveia, I. C. (2023). The sustainable bioactive dyeing of textiles: A novel strategy using bacterial pigments, natural antibacterial ingredients, and deep eutectic solvents. *Gels*, 9(10), 800.

20. Ansari, T. N., & Iqbal, S. (2021). Antibacterial efficiency of naturally occurring dyes and mordants. *Proceedings of the Indian National Science Academy*, 87(2), 408–419.

21. Gupta, D., Khare, S., & Laha, A. (2004). Antimicrobial properties of natural dyes against Gram-negative bacteria. *Coloration Technology*, 120, 167–171.

22. Han, S., & Yang, Y. (2005). Antimicrobial activity of wool fabric treated with curcumin. *Dyes and Pigments*, 64(2), 157–161.

23. Singh, R., Jain, A., Panwar, S., Gupta, D., & Khare, S. K. (2005). Antimicrobial activity of some natural dyes. *Dyes and Pigments*, 66(2), 99–102.

24. van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538.

25. Yusuf, M., Ahmad, A., Shahid, M., Khan, M. I., Khan, S. A., Manzoor, N., & Mohammad, F. (2012). Assessment of colorimetric, antibacterial and antifungal properties of woollen yarn dyed with the extract of the leaves of henna (*Lawsonia inermis*). *Journal of Cleaner Production*, 27, 42–50.

26. Shahmoradi Ghaheh, F., Mortazavi, S. M., Alihosseini, F., Fassihi, A., Shams Nateri, A., & Abedi, D. (2014). Assessment of antibacterial activity of wool fabrics dyed with natural dyes. *Journal of Cleaner Production*, *72*, 139–145.

27. Khan, M. I., Ahmad, A., Khan, S. A., Yusuf, M., Shahid, M., Manzoor, N., & Mohammad, F. (2011). Assessment of antimicrobial activity of *Catechu* and its dyed substrate. *Journal of Cleaner Production*, 19(12), 1385–1394.

28. Ibrahim, N. A., El-Gamal, A. R., Gouda, M., & Mahrous, F. (2010). A new approach for natural dyeing and functional finishing of cotton cellulose. *Carbohydrate Polymers*, 82(4), 1205–1211.